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YHU-1B CATEGORY I PERFORMANCE, STABILITY AND CONTROL TESTS

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UNITED STATES AIR FORCE

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ABSTRACT

The YHU-1B was tested by the Air Force Flight Test Center to gather limited performance and stability and control data to determine whether the helicopter will meet performance guarantees and to insure that no serious stability and control problems exist. The test program consisted of 18 flights totaling 24 hours and 40 minutes flight time between 5 October to 1 November 1960.

The YHU-1B is a single lifting rotor helicopter with a conventional tail rotor manufactured by the Bell Helicopter Company. It is powered by a Lycoming T53-L-5 gas turbine engine with a take-off rating of 960 shaft horsepower. For this program the fuel control was trimmed on the Lycoming test stand so the engine produced a maximum of 1100 shaft horsepower when corrected to standard sea level conditions. Test data from torquemeters showed that the installed engine was capable of producing 1085 shaft horsepower under the same conditions. Production aircraft will incorporate the T53-L-9 engine which is rated at 1100 shaft horsepower.

The design gross weight of this helicopter is 6600 pounds. Overload conditions allow 7660 pounds gross weight with all payload carried internally and 8500 pounds with an external load. During testing gross weight was varied from 5800 to 7660 pounds.

The test aircraft, S/N 58-2078, is a modified HU-1 with HU-1B dynamic components such as the rotor system, tail rotor, transmission, etc. No changes are programmed for the production HU-1B aircraft that will affect performance and stability.

The flying qualities of the YHU-1B are very good. In general, the flying qualities are improved over the earlier HU-1 series. This improvement stems primarily from the absence of the objectionable pitch and roll oscillations which were present in the HU-1. Control sensitivities are approximately equal, with a small decrease in pitch sensitivity being apparent in the YHU-1B. Control response of the two aircraft is approximately equal in pitch and roll, but the HU-1 develops a slightly greater yaw rate.
Static and dynamic stability of the YHU-1B is generally good.

The helicopter meets all contractor guarantees for range, hovering, cruise speed, and service ceiling. However, it is felt that fuel capacity should be increased over the proposed 165 gallons to allow more adequate reserve for flight under instrument conditions. When compared to the HU-1 or HU-1A the YHU-1B has improved altitude performance, cruise speed, range and load carrying capabilities.

A general reduction in vibration is apparent with the YHU-1B. This is particularly significant at the higher airspeeds.

This report has been reviewed and approved

Clayton L. Peterson

CLAYTON L. PETERSON
Colonel, USAF
Director, Flight Test

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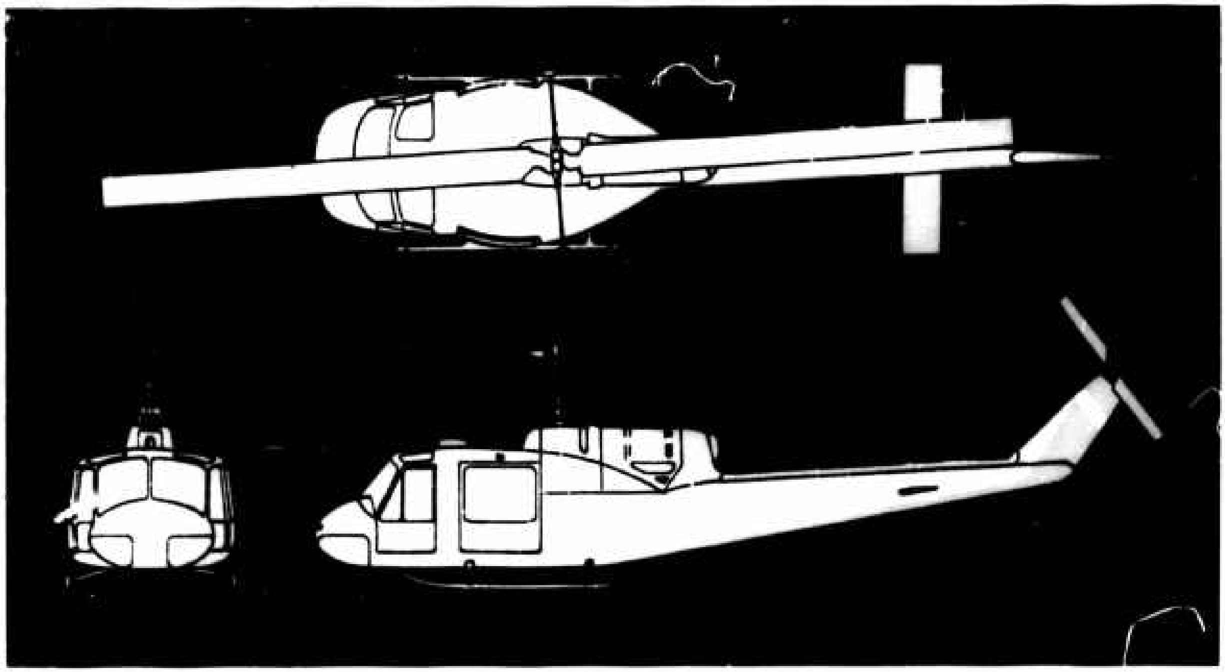

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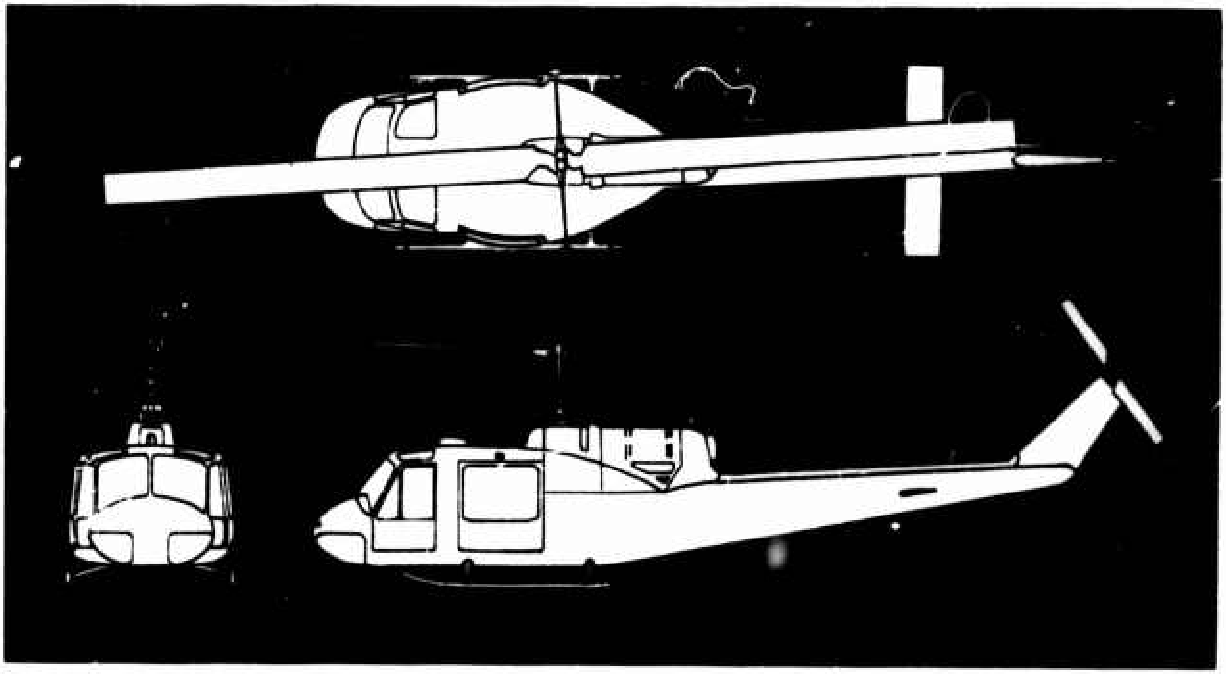


INTRODUCTION

This report presents the results of the Category I performance, stability and control tests performed on YHU-1B S/N 58-2078. These tests were conducted to determine if the helicopter could meet performance guarantees and determine if there were any stability and control deficiencies.

The test program was conducted at the Air Force Flight Test Center, Edwards Air Force Base, California from 5 October to 1 November 1960. Eighteen test flights were made for a total flight time of 24 hours and 40 minutes. The aircraft was maintained by the Bell Helicopter Corporation and the test instrumentation was installed and maintained by the AFFTC.

The YHU-1B is a single lifting rotor helicopter with a conventional tail rotor manufactured by the Bell Helicopter Company, Ft. Worth, Texas. It is powered by a Lycoming T53-L-5 gas turbine engine rated at 960 shaft horsepower at take-off. For the test program the engine fuel control was trimmed on the Lycoming test stand so the engine produced 1100 shaft horsepower. Installed in the helicopter the engine was capable of producing 1085 shaft horsepower at sea level on a standard day at maximum gas producer speed. Production HU-1B aircraft will be equipped with T53-L-9 engines rated at 1100 horsepower.

The design gross weight for this helicopter is 6600 pounds. The aircraft has an overload gross weight of 7650 pounds with only an internal load and a capability of 8500 pounds with an external load. The teetering or see-saw type two-bladed rotor is provided with a gyro stabilizing bar.

During testing the gross weight was varied from 5800 pounds to 7660 pounds and center of gravity position from 125.0 inches (forward) to 138 inches (aft). Flights will be conducted at 8500 pounds during Category II testing.

The control system is hydraulically boosted by a single hydraulic system incorporating irreversible valves. An artificial feel system for the cyclic controls and pedals is provided. A magnetic brake type stick centering system is provided to relieve control forces. The longitudinal cyclic control is connected to the horizontal stabilizer by a push-pull rod.

In this report, control positions are presented in the following manner:

1. Longitudinal and lateral cyclic displacements in inches from a neutral position where the stick is perpendicular to the floor. Full travel from neutral is ±6.5 inches for both axes.

2. Pedal position in inches from a neutral position with pedals aligned fore and aft. Full travel is ±3.5 inches from neutral.

The test aircraft, S/N 58-2078, is a modified HU-1 helicopter. It differs from a standard HU-1 in the following manner:

	HU-1	YHU-1B
Main rotor blade chord	15 in	21 in
Main rotor blade airfoil	NACA 0015	NACA 0012
Height (to top of rotor mast)	11.5 ft	12.5 ft
Transmission power limit	770 SHP at 6400 rpm	1100 SHP at 6600 rpm
Center of gravity range	Sta 128.0 to Sta 137.5	Sta 125.0 to Sta 138.0
Design gross weight	5725 lb	6500 lb

Contractor guarantees and specifications quoted in this report are to be found in Bell Helicopter Company report number 204-947-061A dated 20 January 1960, titled "Detail Specification for HU-1B Utility Helicopter".

Test data was released to the contractor as it became available. Final plots contained in Appendix I of this report were sent to Bell Helicopter Company on 1 June 1961.

PERFORMANCE TEST RESULTS

COCKPIT EVALUATION

The cockpit of the HU-1B is essentially the same as the HU-1A. The major difference is that the instrument panel in the HU-1B is extended 6 inches to the right. This places the instruments more nearly in front of the pilot which is considered desirable. The cockpit is easily entered from either side through wide hinged doors by using the step provided on the forward end of the skid. Access may also be gained to the cockpit from the cargo compartment by stepping over the center console. The collective pitch control is a slight hindrance to normal entry by the co-pilot and offers some obstruction to the pilot when taking his seat from the rear cabin area.

A wide console is provided between the pilot and co-pilot. The feature of functional grouping of switches and controls in individual removable panels is considered excellent. Generally, the instrument panel arrangement is satisfactory. The overhead panel contains the a.c. and d.c. power control switches, lighting controls, miscellaneous switches and the d.c. circuit breaker panel. Operation of these switches and breakers is satisfactory; however, it is necessary to lean over and to one side to read the identification markers.

The following deficiencies which were present in the HU-1A still exist:

1. The pilot and co-pilot's door handles are poorly located. The door handles are behind the pilot and are difficult to reach or operate due to the proximity of the seat to the door. The force required to operate the handle is excessive and the sharp end of the handle digs into the pilot's hand when locking the door. (A 7)[1]

2. The engine flight idle stop release system is unsatisfactory. The button electrically actuates a solenoid to retract a mechanical stop. It is possible to jam the stop by retarding the throttle prior to actuating the button. This requires adding throttle to release the pressure and allow the solenoid to retract the stop. Retarding the throttle while maintaining pressure on the button is difficult and inconvenient. In the event of complete electrical failure, it is not possible to shut down the engine since both the flight idle stop and shut off valves are electrically actuated. A positive mechanical flight idle stop should be provided that can be actuated by the pilot without removing his hand from the throttles. (A 1)

3. The collective pitch is too low when in the full "down" position for starting, run-up, or autorotation. During autorotation the pilot must bend forward and down, restricting his visibility. This condition is more serious in the HU-1B than the HU-1A because of the extended instrument panel. (A 3)

4. The throttle twist grip rotation is excessive. The pilot cannot rotate the throttle from full open to closed (full off) with one normal movement of his hand. Maximum allowable throttle travel is 150 degrees (HIAD J, 2-2.6.2.1). The HU-1B throttle travel exceeds this by approximately 90 degrees. (A 2)

[1] Numbers such as (A 7), etc., represent corresponding recommendation numbers tabulated in the Recommendations section of the report.

5. The a.c. circuit breaker panel located on the side of the console is hidden by the pilot's collective pitch stick and is not illuminated. The overhead circuit breaker panel is not illuminated. The a.c. circuit breaker panel should be relocated on the overhead panel and illumination should be provided for all circuit breaker panels. (A 6)

6. The cargo doors should be provided with jettison capability. These doors open aft by sliding on rollers and could be jammed in a crash landing. (B 3)

ENGINE START

Starting procedure for the gas turbine engine is relatively simple. During the start, the gas producer (consisting of the compressor, the combustors and the compressor turbine) rpm and exhaust gas temperature should be monitored closely along with the oil pressure indicators.

Following electrical power application to start the engine:

1. Place the fuel valve switch and oil valve switch in the "ON" position.

2. Check the fuel control switch in the automatic position.

3. Place the throttle twist grip in any position between ground idle and the flight idle detent.

4. Depress the starter switch and hold until 28 percent gas producer rpm or 400 degrees Centigrade exhaust gas temperature is reached. Operation of the starter switch is restricted to 40 seconds. A normal start will be accomplished in 20 to 25 seconds.

On two occasions a gas producer hang up was encountered. During these hang ups, the gas producer accelerated to ground idle rpm (42 percent) as in a normal start, but the EGT continued to rise to the red line at which time the throttle was placed in cut-off. An immediate successful second start was made following each hung start and no reason for the hung starts was determined. This is a potentially hazardous situation as the start appears normal to the pilot until the engine reaches ground idle speed (40 to 42 percent). It is imperative that the pilot monitor all engine instruments for several seconds after obtaining ground idle rpm to insure that the engine has stabilized at ground idle speed.

The aircraft is not equipped with a rotor brake; therefore, the rotor will begin to turn as the engine is started. After the engine reaches ground idle, the throttle is rotated to the full open position and maintained in that position during normal flight. As the throttle is opened, the rotor will accelerate up to the in-flight rpm range (5800 to 6600 power turbine rpm, 285 to 323 rotor rpm). The desired rpm within this range is selected by the pilot through the use of the power turbine (N_2) governor speed control switch (beep switch). No engine or transmission warm up is required.

LIFT-OFF

During lift-off an unsatisfactory loss of rotor speed was present. This loss occurs whenever collective pitch is applied. This condition is discussed more completely in the section on rpm droop.

The helicopter accelerates rapidly and smoothly from a hover to climb or cruise airspeed. As translational lift is reached, the amount of torque correction or left pedal must be reduced. This appears to the pilot as a large application of right pedal, but is not objectionable because the control forces are light.

HOVERING PERFORMANCE

Hovering performance was determined both in and out of ground effect utilizing tethered hovering and free flight techniques. Data was obtained tethered at a 1 foot and a 59 foot skid height. Rotor speeds were varied from 285 to 323 rpm. Hovering performance is summarized in Fig. 1, Appendix I. This summary plot is based on a free flight point at 13,200 feet and tethered flight points at 2300 feet. Free flight and tethered data are presented non-dimensionally in Fig. 2, Appendix I.

The helicopter exceeds the contractor guarantees for hovering ceiling out of ground effect.

The test aircraft exhibited a temperature rise at the engine bellmouth of 10 degrees Centigrade above ambient while hovering at the 1 foot skid height. This temperature rise is only 2 degrees Centigrade at 59 foot skid height. It is possible that hot exhaust gases are recirculated through the engine when the helicopter is hovered close to the ground. As a result, hovering ceiling in ground effect at the 1 foot skid height is decreased approximately 700 feet from what it would be if the temperature rise were only 2 degrees Centigrade. The contractor should conduct a study to determine whether this 10 degrees C temperature rise can be decreased. (B 4)

The YHU-1B utilizes the same power to hover out of ground effect as the YH-40. Since more power is available, hover ceilings are increased.

LEVEL FLIGHT PERFORMANCE

Level flight tests during this program were performed at density altitudes from 4,000 to 14,000 feet. Gross weight varied from 5600 to 7200 pounds and rotor speeds varied from 290 to 323 rpm. Individual test results are presented in Figs. 6 through 12 and summarized in non-dimensional form in Figs. 3, 4 and 5, Appendix I.

Two tests were performed at the same weight and thrust coefficient (C_T = .00430) with the center of gravity (cg) at the most forward limit (125 inch station) and the mid location (131 inch station). Center of gravity location apparently has a negligible effect on power required. Further tests will be conducted during the Category II to definitely establish the effect center of gravity position on power required.

Range:

Range performance was calculated from fuel flow data and power required curves obtained from level flight tests.

In making the calculations the following specifications for the guaranteed radius of action were used. This includes a full payload of 1230 pounds carried in both directions (crew included):

Engine start gross weight - 6600 pounds

Start engine (with full fuel load of 165 gallons = 1072 pounds)

Warm up and take-off (fuel usage equivalent to 2 minutes at normal rated power)

Cruise out at sea level

Land and shut down

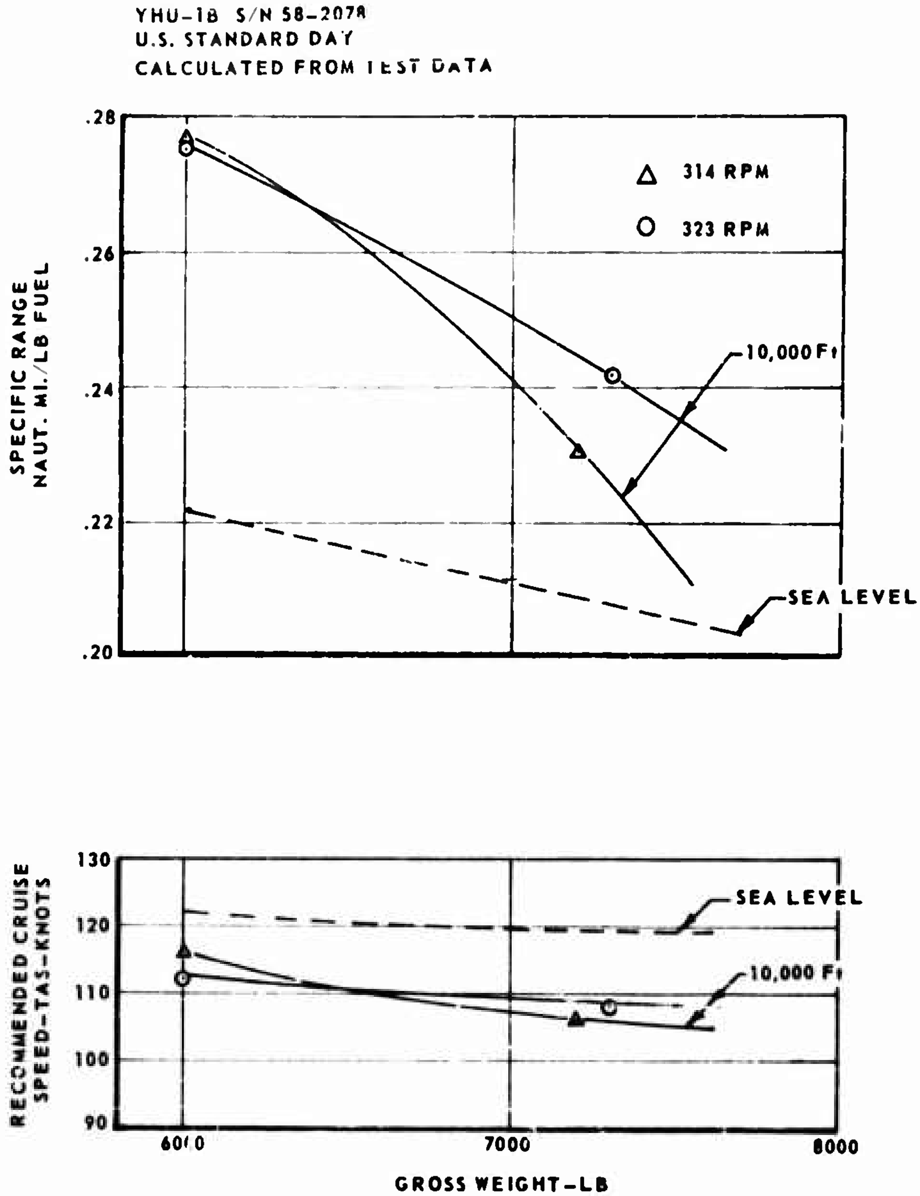
Start engine

Warm up and take-off (fuel usage equivalent to 2 minutes at normal rated power)

Cruise back at sea level

Land and shut down with a reserve of 10 percent of initial fuel load

RANGE SUMMARY



The range for this mission is calculated to be 102 nautical miles at approximately 120 knots TAS and 314 rpm. This meets the contractor's guarantee of 100 nautical miles at a minimum cruise of 100 knots; however, these calculations do not include the 5 percent increase in fuel flow required by MIL-C-5011A. This range is for visual operation in smooth air using test instrumentation and carefully controlled pilot technique. The YHU-1B radius of action is increased approximately 22 nautical miles over that of the HU-1 at sea level. This gain in range is primarily due to the utilization of a higher and more efficient cruise speed made possible by lower vibration levels of the YHU-1B.

The mission requirements state that the aircraft be capable of operating in instrument conditions including light icing. The range of this helicopter will be seriously restricted in instrument flight as Army instrument rules require sufficient fuel to travel to the destination, to the alternate airport, plus 45 minutes of fuel reserve at cruising speed. An increased fuel supply would greatly expand the capabilities of the helicopter. (B 1)

The range summary figures shows a comparison of specific range (nautical air miles per pound of fuel) at sea level and 10,000 feet. The values shown are [illegible] percent of the maximum specifics calculated and the recommended true airspeed is the highest of the two airspeeds at which this specific range value occurs (Reference MIL-C-5011A). For the simulated mission,total range (radius of action) can be increased approximately 35 nautical miles at 10,000 feet; however, the average cruising speed will be 10 knots slower.

Rotor rpm has a negligible effect on range at sea level but a marked effect on cruise speed. For the described mission, range is decreased less than 1 nautical mile if 323 rpm or 307 rpm is used, but best cruising speed is reduced to approximately 110 knots TAS. The higher rpm becomes the more efficient rotor speed above 5000 feet at heavier weights. The summary range figure shows a comparison of range at 10,000 feet for rotor speeds of 314 rpm and 323 rpm.

AUTOROTATION, APPROACH AND LANDING

Autorotational entries were performed with an aft center of gravity at speeds of 90, 100, and 110 knots CAS, and also at a forward center of gravity at 0, 10, 20 and 30 knots. For all conditions tested the entry is characterized by a mild pitch-up and a yaw to the left. Both the pitching and yawing moments are easily controlled . Quantitative rates of descents will be determined during the Category II performance test program.

Autorotational approaches and landings (touchdowns) were made at gross weights varying from 6000 to 7200 pounds. It was determined qualitatively that the minimum airspeed during approach to the flare and landing should be 60 knots IAS at gross weights greater than 6000 pounds. This recommended airspeed will provide sufficient rotor energy to slow the rate of descent and cushion the landing. A steep flare is required to stop the forward speed and break the rate of descent. This flare should be initiated 50 to 75 feet above the ground to avoid striking the tail boom on the ground. As the aircraft is leveled prior to ground contact, collective pitch should be slowly applied to control the rate of descent and cushion the touchdown. The ground sliding distance can be reduced if the collective pitch is lowered after the helicopter is firmly on the ground.

No control deterioration was noticed at any time during the tests; however, during the flare at gross weights above 6500 pounds, rotor speed exceeded 330 rpm. This was the power off limit during the Category I tests. The contractor has since raised this limit to 339 rpm. The feasibility of remaining within this limit will be determined quantitatively in the Category II test program.

Power approach characteristics are normal for a single rotor helicopter. The HU-1B is a relatively low drag helicopter and consequently is difficult to slow from cruise speed to final approach speed. Visibility on final approach is good. The pilot can see the intended landing area during all but the last 20 feet of the approach. There is no increase in the vibration level as the aircraft passes through translational lift. As a hover is reached a large amount of left pedal is suddenly required. Landing from hover is easy and the helicopter touches down nearly level on the skids.

ENGINE RPM DROOP

The engine rpm droop characteristics of the HU-1B are excessive. Whenever collective pitch is applied or a flight maneuver executed, this droop causes an excessive loss of rotor speed. The test aircraft was originally equipped with a standard HU-1A droop compensator cam that was not compatible with the test T53-L-5 engine. This cam was removed and a redesigned model was provided by Bell for the last two flights. This cam reduced the droop to the level of the HU-1A which amounts to a decrease of 10 rotor rpm at lift-off. The unsatisfactory droop characteristics of the HU-1A are discussed in AFFTC-TR-59-33. (A 4)

The power turbine (N_2) governor actuator rate is too slow. The unsatisfactory engine droop characteristics, aggravated by the slow N_2 governor or "beep" rate, makes precision rotor rpm control nearly impossible. The actuator cannot correct rapidly enough for large, rapid collective pitch movements. The collective control would have to move at an extremely slow rate to maintain a safe rotor speed during collective pitch changes. The present beep rate takes approximately 15 seconds from 285 rotor rpm to 323 rotor rpm. This time should be reduced to a maximum of 5 seconds. (A 5)

While this droop is evident during any power change or aircraft maneuver it is unsatisfactory during the lift-off, acceleration to forward flight, climb and landing phases.

During lift-off to a hover approximately 10 rotor rpm (200 power turbine or N_2 rpm) are lost and another 10 rotor rpm are lost as collective pitch is added to accelerate into forward flight and climb. In a maximum performance climb at 323 rotor rpm (6600 N_2 rpm), maximum available gas producer speed cannot be obtained. At 323 rotor rpm, N_1 rpm was 1½ to 2 percent below the maximum. Maximum N_1 rpm can be obtained by bleeding rotor speed to 314 rpm (N_2 = 6400 rpm).

When the collective pitch is lowered and a slight flare initiated to slow the aircraft for landing, the rotor rpm will overspeed unless N_2 rpm is beeped down. The same condition is encountered when a final approach descent is initiated. As power is re-applied, the governor setting must be beeped up to provide the desired rotor rpm. If the helicopter is hovered using 323 rotor rpm, the governor setting must be reduced when the collective pitch is lowered to prevent overspeeding the rotor.

The contractor should initiate action to improve the engine droop characteristics and the governor actuator rate. (A 4)

VIBRATION

The vibration characteristics of the YHU-1B in level flight are a marked improvement over those of the HU-1A. At all weights and altitudes tested the helicopter was power limited rather than vibration limited. Vibration appears to change little with cg change. All vibration characteristics were evaluated qualitatively from pilot comments.

AIRSPEED CALIBRATION

A boom airspeed system was installed for test purposes. This test system and the standard airspeed system were calibrated in level flight throughout the speed range to a maximum of 120 knots IAS. The calibration was accomplished by the ground speed course method. Results of this calibration are shown in Fig. 39, Appendix 1.

The calibration of the standard airspeed system shown in Fig. 39, Appendix I is not representative of the production HU-1B system. Prior to the last flight of the test program a second baffle was added at the standard system static source. The change is an attempt to produce a constant error. This new system will be evaluated in the Category II test program.

STABILITY AND CONTROL TEST RESULTS

HOVERING

The flying qualities while hovering are not entirely satisfactory; however, the YHU-1B is improved over the HU-1. The oscillations in pitch and roll, which were objectionable in the HU-1, are negligible, but random oscillation in yaw still exists which makes precision hovering in ground effect difficult. This yawing oscillation decreases at skid heights above 30 feet.

HOVERING DYNAMIC STABILITY

The dynamic stability characteristics were determined by 1 second pulse type control inputs about all axes. Prior to any control displacements, the aircraft was brought to a stabilized hover for several seconds.

Following a 1 inch forward longitudinal pulse the aircraft pitches down, moves forward, and then pitches up at translational lift. The resulting longitudinal oscillation is lightly damped with a period of approximately 5 seconds. The downward pitching is accompanied by left yawing and rolling which reverses when the aircraft pitches up. Following a 1 inch aft pulse, the aircraft pitches up, moves aft and pitches down. The aircraft rolls and yaws slightly right on the upward pitch and as the aircraft noses down, develops a right yaw of such magnitude that the maneuver must be discontinued.

Pedal pulses result in a nearly deadbeat oscillation in yaw. The accompanying roll oscillation is initially opposite in direction to the pulse and heavily damped. Lateral pulses cause a divergent yawing in the direction of the pulse.

Time histories of these pulses are shown in Figs. 16 through 21, Appendix I.

All tests were performed at approximately 6600 pounds gross weight with a mid center of gravity at a rotor speed of 323 rpm.

HOVER CONTROLLABILITY

Control sensitivity during hover was determined by measuring the immediate maximum angular acceleration resulting from various step type control displacements from trim about all three axes. Control sensitivity about all axes is adequate. The following control sensitivities were obtained for a 1 inch control displacement from trim.

Axis	Sensitivity deg/sec^2/in	Time to Reach Maximum Acceleration - sec
Pitch	10	0.4
Roll	16	0.4
Yaw	40	0.4

No noticeable delay occurs between control movement and aircraft response. No "slop" or play is apparent in the control systems and control sensitivity is equal for control displacements in either direction. Results of tests at a mid center of gravity position and rotor speeds of 323 rpm are presented in Figs. 22 through 27, Appendix I.

Control response during hover was determined from various step type control inputs from trim about each axis. The resultant immediate maximum angular velocity was measured. Control response about all three axes is satisfactory. The following rates were measured:

Axis	Response deg/sec/in	Time to Reach Maximum Rate - sec
Pitch	9	2.0
Roll	8	0.9
Yaw	45	7 to 8

Longitudinal steps produce a pitch-up for aft and a pitch down for forward stick movements that continue until the maneuver is discontinued. An aft step is accompanied by a random yaw and roll that is initially to the right. A forward longitudinal step results in a yaw and roll that is also random but initially to the left.

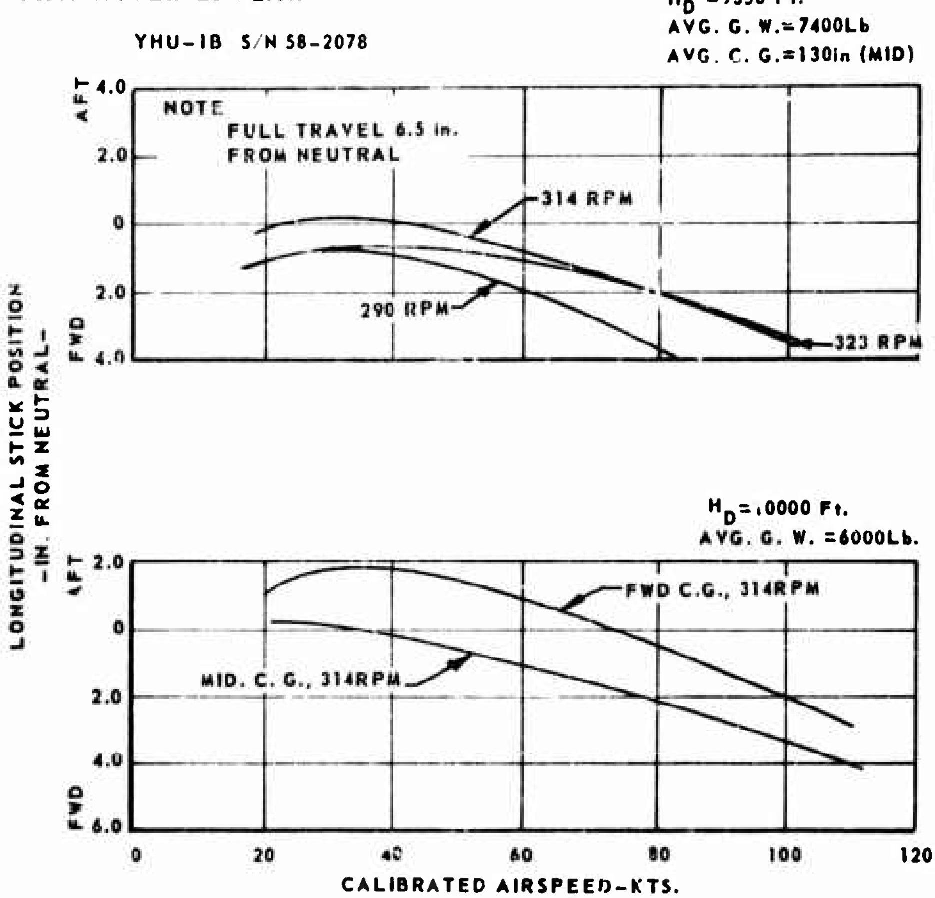
Directional steps produce a yaw in the direction of the step that continues until recovery. The maximum rate is reached in 7 to 8 seconds. The directional control displacements also produce random oscillations in pitch and roll With a lateral step the aircraft rolls in the direction of the displacement and a yaw slowly develops in the direction of the roll.

LEVEL FLIGHT

The level flight flying qualities are very good. Positive longitudinal stability, both static and dynamic, is demonstrated by the capability of the aircraft to fly hands off in light turbulence at speeds up to 100 knots CAS. The aircraft exhibits strong static and dynamic stability allowing pedal fixed turns to be easily accomplished. Roll rate is adequate even though the roll develops and then stops before continuing. This condition was also noted in the HU-1A.

Stability and control characteristics were determined for airspeeds from 34 to 104 knots CAS at average density altitudes of 5,000 and 10,000 feet. Gross weights for these flights were approximately 6000, 6600 and 7400 pounds at mid cg. Rotor speed was varied from 285 to 323 rpm. Longitudinal dynamic stability was tested qualitatively at forward and aft center of gravity locations. Prior to any control displacement the aircraft was stabilized in level flight at the trim airspeed with zero sideslip.

LONGITUDINAL CONTROL
POSITION IN LEVEL FLIGHT



STATIC STABILITY

Control positions during level flight were recorded as a function of airspeed at forward, mid and aft cg locations and at rotor speeds from 290 to 323 rpm. All cyclic control positions are measured from a position vertical to the floor. Full longitudinal cyclic travel is 6.5 inches forward and aft from vertical; full lateral travel is 6.5 inches left and right from vertical. Pedal travel is measured from neutral and full travel is 3.5 inches right and left from neutral. The apparent static longitudinal stability is positive above 30 knots CAS (Figs. 28 and 29, Appendix I). At airspeeds below 30 knots apparent static longitudinal appears to be slightly negative. A change of rotor speed from 290 to 314 rpm requires the cyclic to be moved aft 1 to 2 inches to maintain the same airspeed. The same is true of a change from 290 to 323 rpm for airspeeds from 50 to 90 knots. Lateral cyclic and pedal positions were normal at all speeds. An aft center of gravity location requires that the cyclic stick be moved approximately 2 inches farther right than for a forward cg at the same weight when the airspeed is less than 60 knots CAS. This lateral movement decreases to approximately

1 inch at 110 knots. Collective pitch control was found to be adequate at all rotor speeds.

The accompanying figure shows the effect of center of gravity location on longitudinal stick position at various airspeeds. The helicopter had adequate control margin during all Category I testing within the observed 120 knot IAS limit.

Static directional stability was investigated by obtaining the pedal position necessary to maintain various sideslip angles at several airspeeds. The same test was conducted using the contractor recommended climb speeds during both climb and descent. Results are presented in Figs. 30 through 34, Appendix I. The HU-1B has strong positive static directional stability. Good directional control effectiveness and light pedal forces assist the pilot in maneuvering the helicopter and in maintaining a heading.

LEVEL FLIGHT CONTROLLABILITY

Control sensitivity of the YHU-1B during level flight was determined by measuring the immediate angular acceleration resulting from various step type control displacements from trim about all three axes. These steps were performed at 34, 64 and 104 knots CAS at a rotor speed of 323 rpm. The directional steps for all speeds tested were repeated at rotor speeds of 285 rpm. Control sensitivity about all axes is satisfactory and approximately equal to those of the HU-1 except for slight decrease in pitch. The following sensitivities were obtained for a 1 inch displacement from trim.

Axis	Sensitivity $deg/sec^2/in$	Time to Reach Maximum Acceleration - sec
Pitch	10	0.4
Roll	28 right 26 left	0.4
Yaw	30	0.4

Results of these tests are presented in Figs. 22 through 27, Appendix I.

Control response of the YHU-1B was determined by measuring the immediate maximum angular velocity from the step type control inputs. Control response about all three axes is satisfactory. The HU-1 develops a slightly larger yaw rate, but the two aircraft have approximately the same response in pitch and roll. The following rates were measured:

Axis	Response deg/sec/in	Time to Reach Maximum Rate-sec
Pitch	9.0	1.9
Roll	13 left 16 right	1.2
Yaw, 323 rpm	11	1.1
285 rpm	11	1.1

Step inputs were made about all axes from stabilized level flight at airspeeds of 34, 64 and 104 knots CAS and rotor speeds of 323 rpm. Following a 1 inch forward longitudinal step, the aircraft pitches down with the pitch rate decreasing as airspeed increases. The pitching motion is accompanied by a gentle rolling and yawing to the left. An aft step results in opposite reactions about all axes. A 1 inch right lateral step produces a right roll followed by right yawing motion until recovery is executed. With a left lateral step a left roll develops, however, the yaw is initially slightly right and then becomes left until recovery from the maneuver.

Pedal steps were performed at airspeeds of 34, 64 and 104 knots CAS at rotor speeds of 285 and 323 rpm. At 34 knots a 1 inch directional step generates a hesitating turn in the direction of the step followed by an uneven rolling motion in the direction of the turn. This occurs at both 285 and 323 rpm.

A 1 inch left directional step at 64 knots CAS and a rotor speed of 285 rpm produces reactions similar to those that occur at 34 knots. A right directional step at 285 rpm produces a right yaw that is stopped when a left roll develops. When the yaw is stopped the aircraft rolls right and the right yaw starts again.

A 1 inch left directional step at 104 knots CAS and a rotor speed of 323 rpm produces a small left turn and right roll. This right roll causes the left turn to stop and reverse to a right turn. A right step at 323 rotor rpm and steps in both directions at 285 rotor rpm produce a turn that becomes a steady state sideslip when sufficient roll has developed to stop the turn.

All directional steps cause a very slight nose down pitch.

LEVEL FLIGHT DYNAMIC STABILITY

Pulses to evaluate the dynamic stability were made from stabilized flight conditions at the same airspeeds and rotor speeds as the step inputs. Dynamic characteristics were determined to be good.

The short period oscillations excited by a longitudinal pulse are heavily damped. An aft pulse produces a heavily damped pitching motion initially up, accompanied by a well damped left rolling motion and a change in heading to the right until recovery is executed. A forward pulse produces the opposite reaction. During several of these maneuvers a long period oscillation, which was very lightly damped, was recorded. The period of this phugoid oscillation is approximately 27 seconds.

Directional pulses produce a heavily damped yawing motion initially in the direction of the pulse accompanied by a well damped rolling motion initially in the opposite direction of the yaw. The aircraft pitches up for a right yaw and down for a left yaw. These characteristics are summarized in Figs 35 and 36, Appendix I.

A left lateral pulse produces a heavily damped initially left rolling motion and a turn to the left until recovery is effected. A right pulse produces a heavily damped right rolling motion and a left turn that peaks in 5 seconds and then becomes a steady left sideslip.

SIDEWARD AND REARWARD FLIGHT

Tests were conducted to determine the hovering capabilities of the helicopter when operating close to the ground in crosswinds and tail winds. The sideward and rearward test flights were conducted at a gross weight of 7600 pounds, at the most forward cg (125 inches), and at a rotor speed of 323 rpm. These tests were flown in ground effect. Control positions obtained during these tests are presented in Figs. 37 and 38, Appendix I.

The YHU-1B moves easily into sideward flight with small pedal manipulations required below 10 knots TAS to maintain the desired heading. When translational lift occurs (10 to 20 knots), small, rapid pedal movements are required. Approaching translational lift oscillations in roll, yaw and pitch are encountered. When going to the left, above the speed for translation, there is a sudden requirement for a large amount of right rudder. For flight to the left 2.8 inches of right pedal are required at 30 knots, and 1.8 inches of left pedal are necessary for 30 knots to the right.

During sideward flight the cyclic stick moves aft and in the direction of flight laterally. Aft cyclic movements reach a maximum at approximately 27 knots TAS in either direction and then decrease slightly at 30 knots. Lateral cyclic stick position increases positively to approximately 27 knots at which point a slight reversal occurs. Collective pitch control is less than for a hover, with approximately the same amount necessary for similar speeds in either direction.

The HU-1B accelerates rearward nearly as easily as it does forward. There is a tendency to turn into the relative wind that requires rapid pedal movements to control. A nose down pitching moment at translational lift requires an increase of 1.4 inches of aft cyclic to control. As speed increases longitudinal stick position moves from 2 inches aft of neutral at hover to a maximum of 1.3 inches or 10 percent from full aft at 30 knots TAS to the rear.

CONTROL FORCES AND TRIMMING

Control forces are satisfactory with the trim system on or off. Control forces are high with the control boost system off but no feedback from the rotor system is present. Boost-off control forces of the YHU-1B are slightly higher than those of the HU-1A but sufficient control is available to hover and land.

The trim system in the test aircraft is satisfactory at speeds from hover to 100 knots IAS. In this regime the centering device quickly removes all forces and the aircraft can be flown hands off for short periods. In light turbulence, however, at speeds greater than 100 knots the cyclic stick falls forward unless an excessive amount of friction is applied. When the needed friction is used to hold the stick, control forces become large. The trim system should be redesigned to give the same hands off capability at speeds of 120 knots or greater since this is the most efficient cruise speed for the helicopter at sea level. (B 2)

CONCLUSIONS

The YHU-1B helicopter is much improved over the earlier HU-1 and HU-1A series. The major improvements are:

1. Lower vibration levels.
2. Increase cruise speed and range.
3. Greater altitude performance.
4. Increased weight carrying capability.

Flying qualities of the YHU-1B are improved over the earlier models. This is primarily due to the absence of the objectionable pitch and roll oscillations which were present in the HU-1. Control sensitivities and response are approximately equal; however, in the HU-1 pitch sensitivity and yaw rate is slightly greater.

The HU-1B meets guarantees of range, cruise speed, and service ceiling. The hovering capabilities are good and meet guarantees; however, hovering ceiling in ground effect is reduced approximately 700 feet by a 10 degree decrease in bellmouth temperature over that occurring at the same conditions out of ground effect. This temperature increase may be caused by hot exhaust gases recirculating through the engine.

The contractor has made no improvement in engine droop compensation. The excessive engine droop, aggravated by a slow power turbine (N_2) governor actuator rate, makes precision rotor rpm control nearly impossible. The N_2 actuator, which takes approximately 15 seconds to change rotor speed from 285 rpm to 323 rpm, cannot correct rapidly enough following large, rapid collective pitch movements.

The engine flight idle stop release system is unsatisfactory. This complaint was also made in YH-40 report AFFTC-TR-59-33 and HU-1 report AFFTC-TR-60-57. It is possible to jam the stop by retarding the throttle prior to actuating the electrical system which removes the stop. Throttle travel is excessive by HIAD standards, (HIAD 3.2.2.6.2) and tends to make jamming the stop more probable. Futhermore a complete electrical failure would make engine shutdown impossible since no mechanical means of engine fuel shutoff is provided.

RECOMMENDATIONS

A. It is recommended that the following be action be taken as soon as possible:

1. Install a positive mechanical flight idle stop that can be actuated by the pilot without removing his hand from the throttle (page 3)

2. Limit the throttle twist grip rotation so that the pilot can rotate the throttle from full off to full open with one normal movement of his hand (page 3)

3. Raise the collective pitch stick (page 3)

4. Improve the droop characteristics to maintain ± 2 rotor rpm variation from the selected governed speed throughout the governing range under all flight conditions (page 8)

5. Reduce the time to change rotor speed from 285 rpm to 323 rpm to approximately 5 seconds (page 8)

6. Move the a.c. circuit breakers to the overhead panel and illuminate all circuit breakers (page 4)

7. Make the pilot's and co-pilot's door handles easier to operate (page 3)

B. It is recommended that studies be initiated as soon as possible to accomplish the following items:

1. Increase fuel capacity to make instrument flights more feasible (page 7)

2. Redesign the trim system so hands off flying capabilities are available at 120 knots IAS (page

3. Make the cargo doors jettisonable (page 4)

4. Decrease the engine inlet temperature while hovering in ground effect (page 5)

APPENDIX I

data analysis methods

PERFORMANCE

General:

The equations and procedures used to correct the performance of this helicopter from test conditions to US standard atmosphere conditions are briefly described in this section.

Dimensional analysis of the major items affecting helicopter performance will yield two sets of dimensionless variables which may be used to present performance data in non-dimensional form. The C_P, C_T, method is used in this report. It should be noted that this non-dimensional method is useful only where compressibility effects are not significant. These variables are defined as follows:

$$C_P = \frac{SHP \times 550}{\rho A (\Omega R)^3}$$

$$C_T = \frac{W}{\rho A (\Omega R)^2}$$

$$\mu = \frac{V_T}{\Omega R}$$

where:

SHP = output shaft horsepower

ρ = air density - slugs/ft^3

A = rotor disc area - ft^2

Ω = rotor angular velocity - rad/sec

R = rotor radius - ft

W = gross weight - lb

V_T = true airspeed - ft/sec

Hovering:

The hovering data was obtained in tethered flight at two heights, one in and out of ground effect, at a pressure altitude of 2300 feet. Hovering was conducted in zero wind conditions. This data was reduced to C_P, C_T and is presented in Figure 1. The weight used to compute C_T consisted of the weight of the helicopter and tethering components plus the force (pounds) applied to the tie-down cable.

Level Flight:

The basis for correction of level flight speed power data lies in the C_P, C_T method. Each speed power was flown at an approximate C_T. This involves increasing altitude as fuel is burned. The data was corrected for C_P to an exact, constant C_T as follows:

$$C_{P_s} = C_{P_t} + \frac{\Delta C_P}{\Delta C_T} (C_{T_s} - C_{T_t})$$

where $\Delta C_P / \Delta C_T$ is the slope of the C_P versus C_T curve at constant μ and the subscripts s and t denote standard and test conditions, respectively. Shaft horsepower standard was then calculated using a standard rotor speed.

The non-dimensional parameters C_P, C_T and μ are used for correlation of the level flight data.

For each flight airspeed and power required are reduced to non-dimensional form and a plot is made of C_P versus at the average C_T flown. A curve is faired through the points and faired line values are used to construct a carpet plot of C_P versus C_T. On this plot lines of constant μ are then faired through the various test curves, thus defining power required for any altitude, gross weight, airspeed and rotor rpm. Non-dimensional summary plots are prepared from this carpet plot. These plots, Figs. 2, 3 and 4, and SHP versus V_T are presented in Appendix I.

Fuel flow data was reduced to fuel flow per SHP at various altitudes. These values were corrected to sea level conditions at the compressor inlet and are presented in the SHP/$\delta\sqrt{\theta}$ versus $W_f/\delta\sqrt{\theta}$ curve, Fig. 13.

Where:

SHP = output shaft horsepower

W_f = fuel flow - lb-fuel/hour

δ = ratio of test bellmouth inlet pressure to standard sea level pressure

θ = ratio of test bellmouth inlet temperature to standard ambient temperature at sea level

SHP/$\delta\sqrt{\theta}$, $W_f/\delta\sqrt{\theta}$, and $N_1/\sqrt{\theta}$ are designated as "Referred" shaft horsepower, "Referred" fuel rate, and "Referred" fuel rate, and "Referred" gas producer rpm in this report.

Power Determination:

The T53 gas turbine engine incorporates a hydro-mechanical torquemeter as an integral part of the reduction gearing on the compressor end of the engine. This torquemeter is essentially a piston which supplies pressure, in proportion to the output torque, on the contained hydraulic oil. This oil pressure is normally indicated on the pilot's panel and is used as an indication of engine torque. To obtain a more accurate indication of torque, the pressure of the oil vapor behind the piston is also measured and the difference between this pressure and the hydraulic oil pressure is found. The engine manufacturer calibrates the oil pressure and oil vapor pressure as a function of output shaft torque during the test cell qualification of each engine. Engine power output and fuel consumption characteristics are also determined during test cell operation. For the test engine these characteristics are presented in Figs. 1 through 3, Appendix II. The tests by the engine manufacturer are conducted using ideal intake and exhaust ducts. Consequently, compressor inlet conditions are considered equal to ambient conditions.

The equation from which output shaft horsepower was determined from in-flight torquemeter readings was derived as follows:

$$SHP = \frac{2\pi}{12 \times 3300} \times N_e T$$

where:

SHP = output shaft horsepower

N_e = output shaft rotational speed - rpm

T = output shaft torque - in-lbs

The torquemeter calibration as presented in Figure 1, Appendix II indicates that torque is the following function of torque pressure:

$$T = 236.5\,\Delta P$$

where

ΔP = torquemeter pressure minus inlet housing pressure - psi

Rotor speed is determined from engine output shaft speed as follows:

$$N_r = N_e/20.37$$

where

N_r = rotor rotational speed - rpm

Substituting the last two equations in the first, an equation for determining output shaft horsepower may be developed:

$$SHP = \frac{2\pi \times 236.5 \times 20.37}{12 \times 33000}$$

$$X N_r \Delta P = .0764 N_r \Delta P$$

During the test program, torque pressure from which SHP was calculated, was measured by taking the difference between the hydraulic oil pressure (high torque) and the oil vapor pressure (low torque). Engine characteristics were defined by curves of:

$$\frac{SHP}{\delta\sqrt{\theta}} \text{ vs } \frac{N_1}{\sqrt{\theta}}, \quad W_f/\delta\sqrt{\theta} \text{ vs } \frac{SHP}{\delta\sqrt{\theta}}$$

where

SHP = output shaft horsepower as calculated from torque pressure

N_1 = gas producer speed - percent

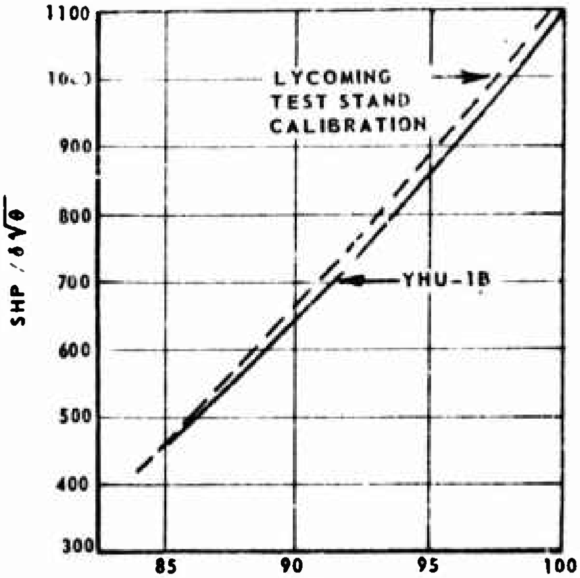
δ = ratio of test bellmouth inlet pressure to standard pressure at sea level

θ = ratio of test bellmouth inlet temperature to standard temperature at sea level

The accompanying figure shows a discrepancy between the characteristics of the test engine as determined by the manufacturer during the test stand calibration runs and those determined by flight tests.

ENGINE CHARACTERISTICS

T-53-L5 S/N LE03007



$N_1/\sqrt{\theta}$ - %

δ AND θ BASED ON BELLMOUTH INLET CONDITIONS

Test instrumentation was rechecked and found to be operating properly. Similar discrepancies have been found in previous tests (Reference AFFTC-TR-56-15 and AFFTC-TR-59-33).

Flight test data indicates that maximum power is available at 100 percent N_1 rather than 99.6 percent N_1 found by the engine manufacture at sea level standard day conditions. Limit N_1 for this engine is 100 percent. Maximum power available, Figure 15 of this Appendix, was calculated using flight test data.

STABILITY AND CONTROL

Definitions:

The stability and control characteristics of the YHU-1B helicopter are discussed in terms of static stability, dynamic stability and controllability. These terms are defined as follows:

1. Longitudinal static stability is the apparent stability determined from an analysis of longitudinal control position with respect to airspeed. The collective position was treated as an independent variable. For each test point the collective stick position was determined by the position normally used in flight. A longitudinal control position-airspeed gradient obtained in this manner determines apparent static stability. The stability is called apparent because it is an indication of the longitudinal static stability from the pilot's viewpoint, but is not a direct measure of the speed stability or angle of attack stability of the aircraft. Static lateral directional stability was obtained by measuring control positions in steady-state sideslips.

2. The dynamic stability of the helicopter was determined by recording aircraft behavior, displacement, rate and angular acceleration following an artificial disturbance. This artificial disturbance was the result of a pulse type control input. The pulse input was made by rapidly displacing the control approximately 1 inch from trim position, holding for approximately 1 second, then rapidly returning to the trim position and holding the control fixed. A mechanical jig was used to guarantee precise input. The dynamic behavior of the aircraft in hover is presented by time histories (Figs. 15 through 20). The parameters presented are indicated values traced from the oscillograph records. The longitudinal and directional dynamic stability data was reduced to damping ratios and period. The oscillations following a pulse input are heavily damped; therefore the method of counting cycles for the initial amplitude to damp to some fraction was not used to determine damping ratio. The time rise method was used to determine an approximate damping ratio. In this method the damping ratio (ξ) is found by the relationship of T_2/T_1 to ξ where T_1 is the time for the response to reach 20 percent of the steady state value and T_2 is the time to reach 74 percent of the steady state value. The accuracy of this method depends on how well the beginning of the response can be identified. The periods were determined from the following relationship:

$$T_n = T_d \sqrt{1 - \xi^2}$$

where

T_n is the undamped natural frequency

T_d is the damped natural frequency

3. Controllability is treated in two parts, namely sensitivity and response. Sensitivity is defined as the maximum angular acceleration (degrees per second^2) of the aircraft per inch deflection of the cockpit control. Time to reach the maximum acceleration is included. Response is defined as the maximum angular velocity (degrees per second) of the aircraft per inch deflection of the cockpit control. Time to reach the maximum rate is included. The control deflections were stick fixed, sudden, step type inputs. The step input was made by rapidly displacing the control from trim and holding the control fixed until recovery was necessary. A mechanical jig was used to insure precise inputs.

GRAPHIC TEST RESULTS

Performance Plots

Figure No.

Stability and Control Plots

Fig. No. 1

Summary Hovering Performance

YHU-1B S/N 58-2078

323 Rotor RPM

Standard Day

OGE - Out-of-Ground Effect

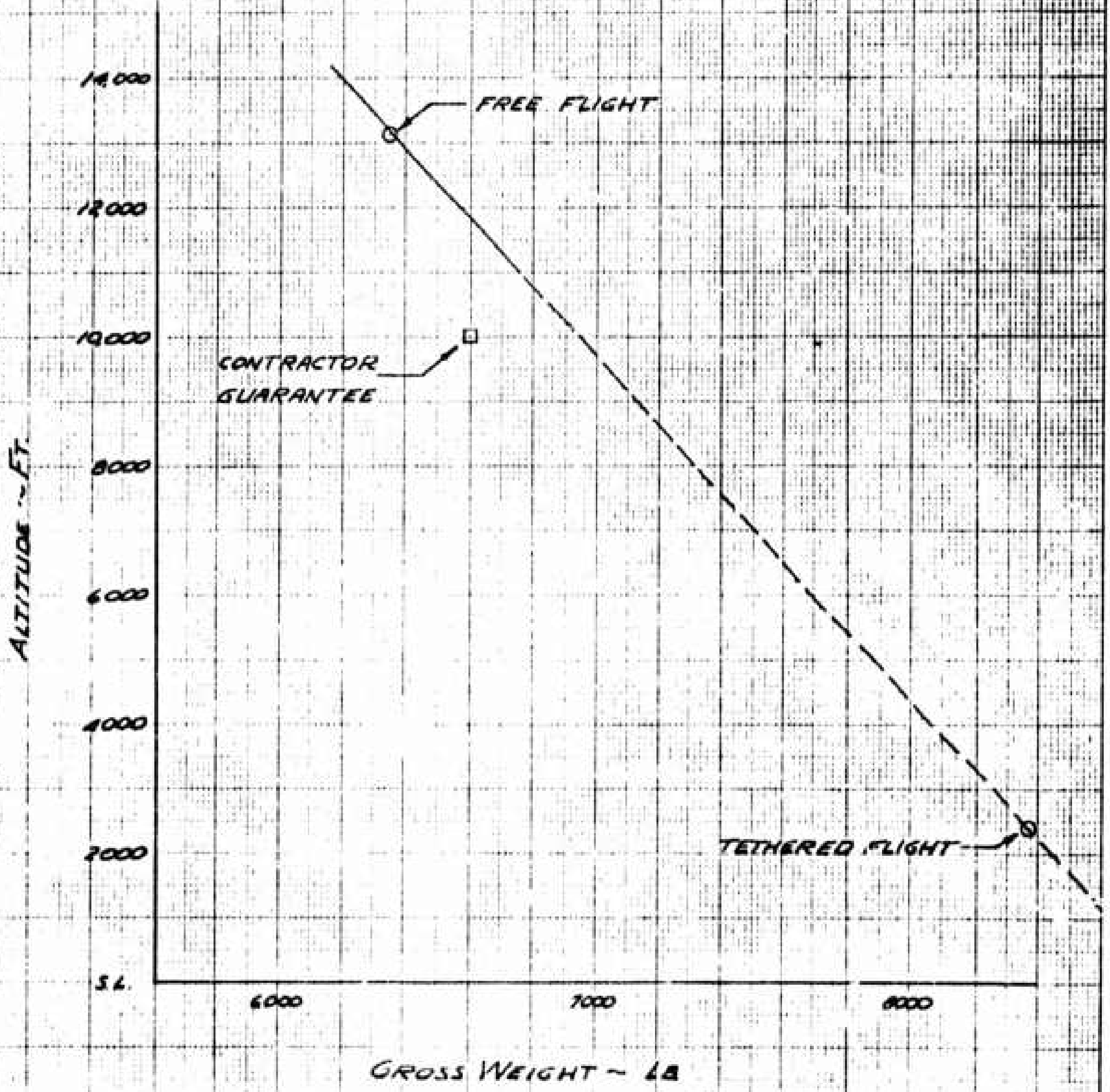
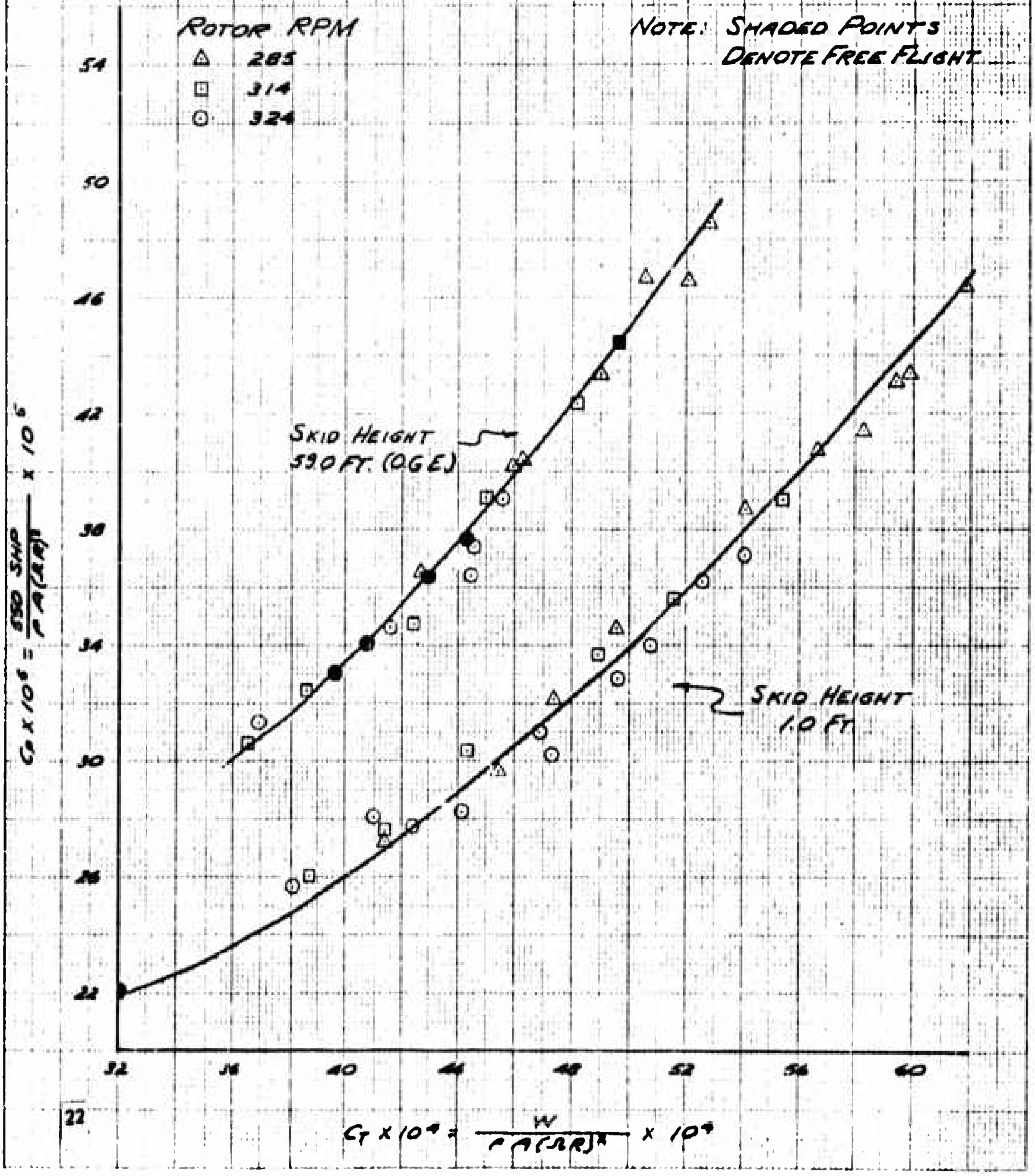


FIG. No. 2
NON-DIMENSIONAL HOVERING PERFORMANCE
YHU-1B S/N 58-2078
TETHERED FLIGHT



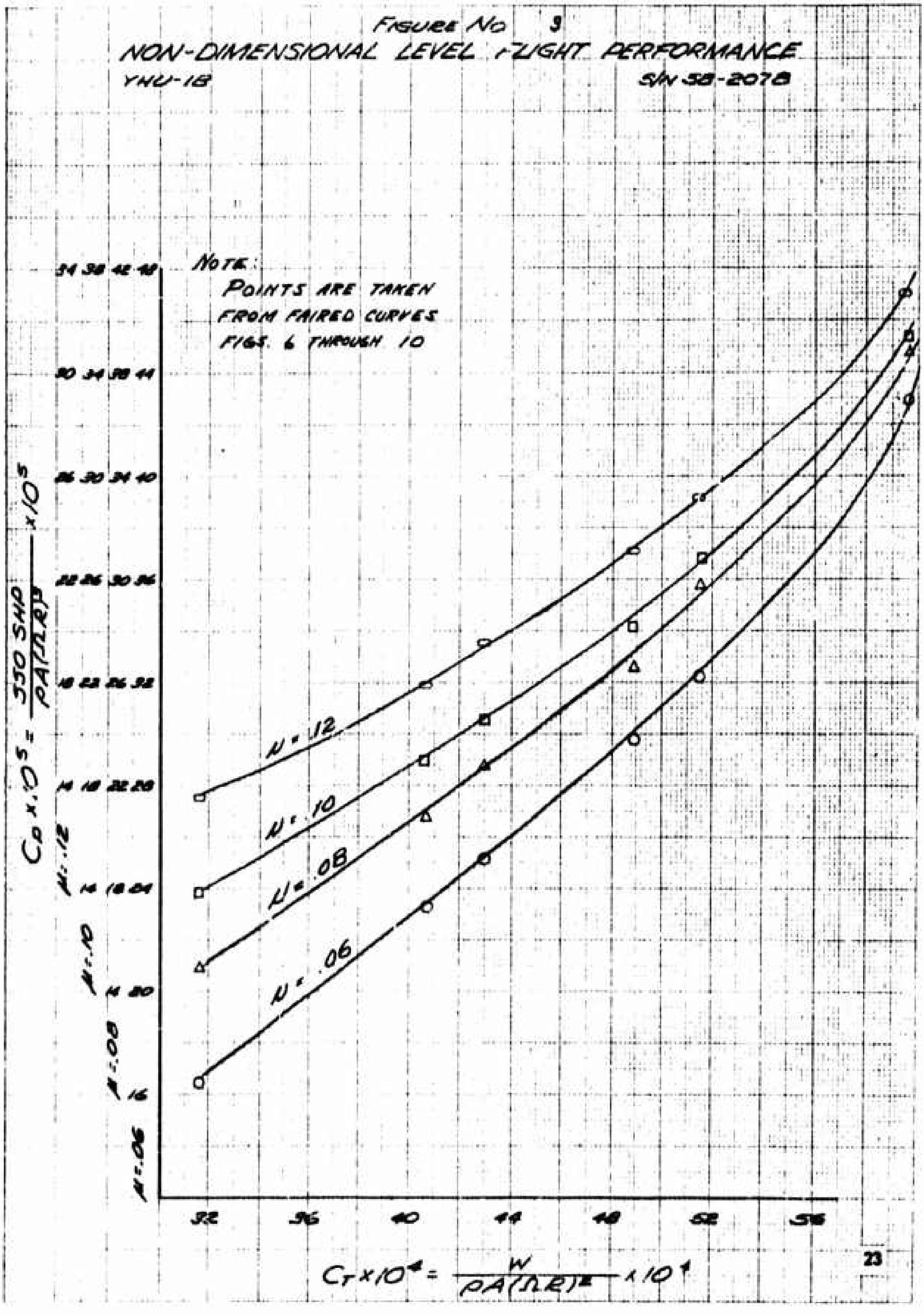
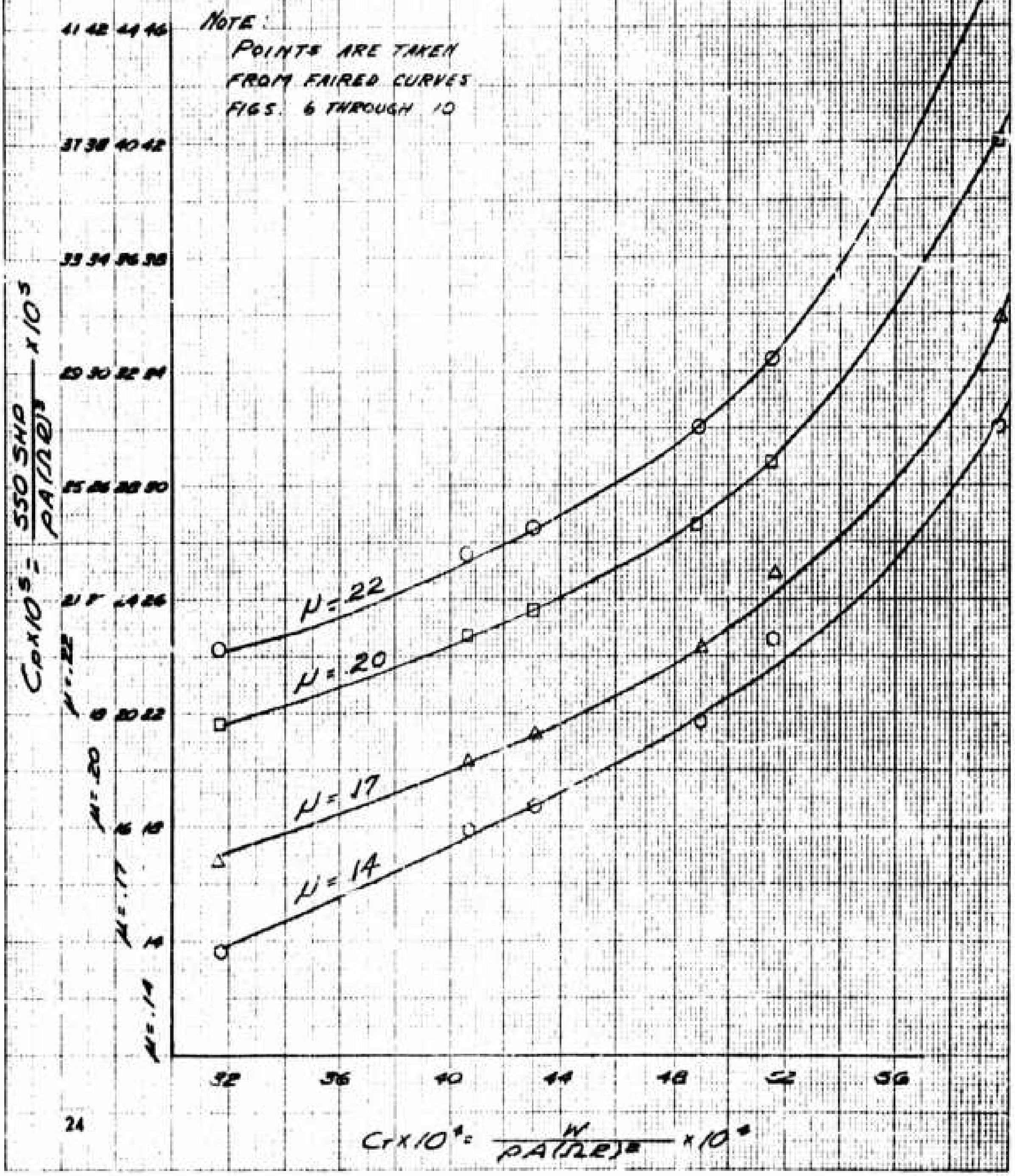


FIGURE NO 3
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE
YHU-1B
S/N 58-2078
NOTE:
POINTS ARE TAKEN
FROM FAIRED CURVES
FIGS. 6 THROUGH 10
μ = .12
μ = .10
μ = .08
μ = .06
$C_D \times 10^5 = \frac{550\ SHP}{\rho A (\Omega R)^3} \times 10^5$
$C_T \times 10^4 = \frac{W}{\rho A (\Omega R)^2} \times 10^4$
32
36
40
44
48
52
56

FIGURE NO 4

NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE

YHU-1B S/N 58-2078



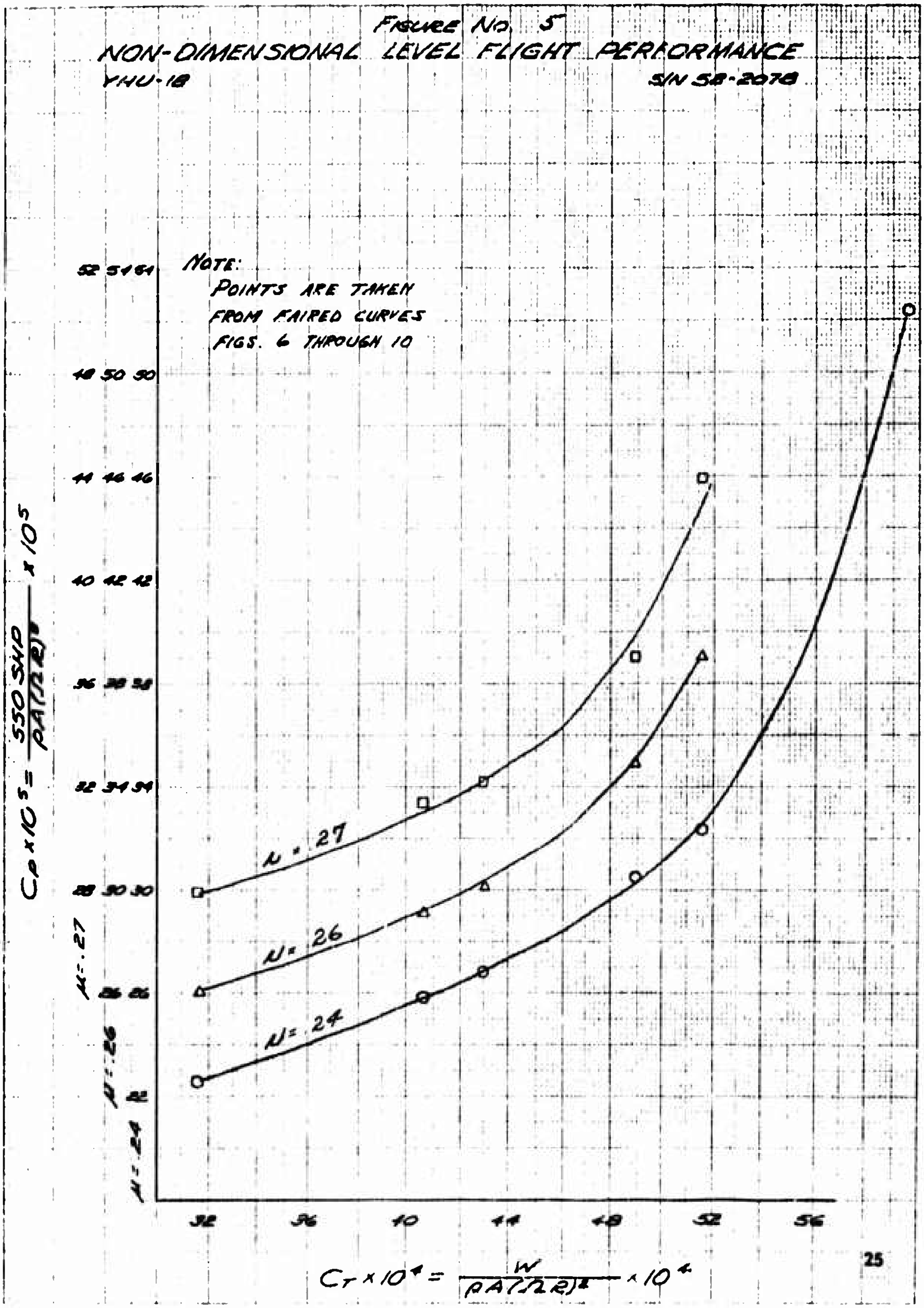


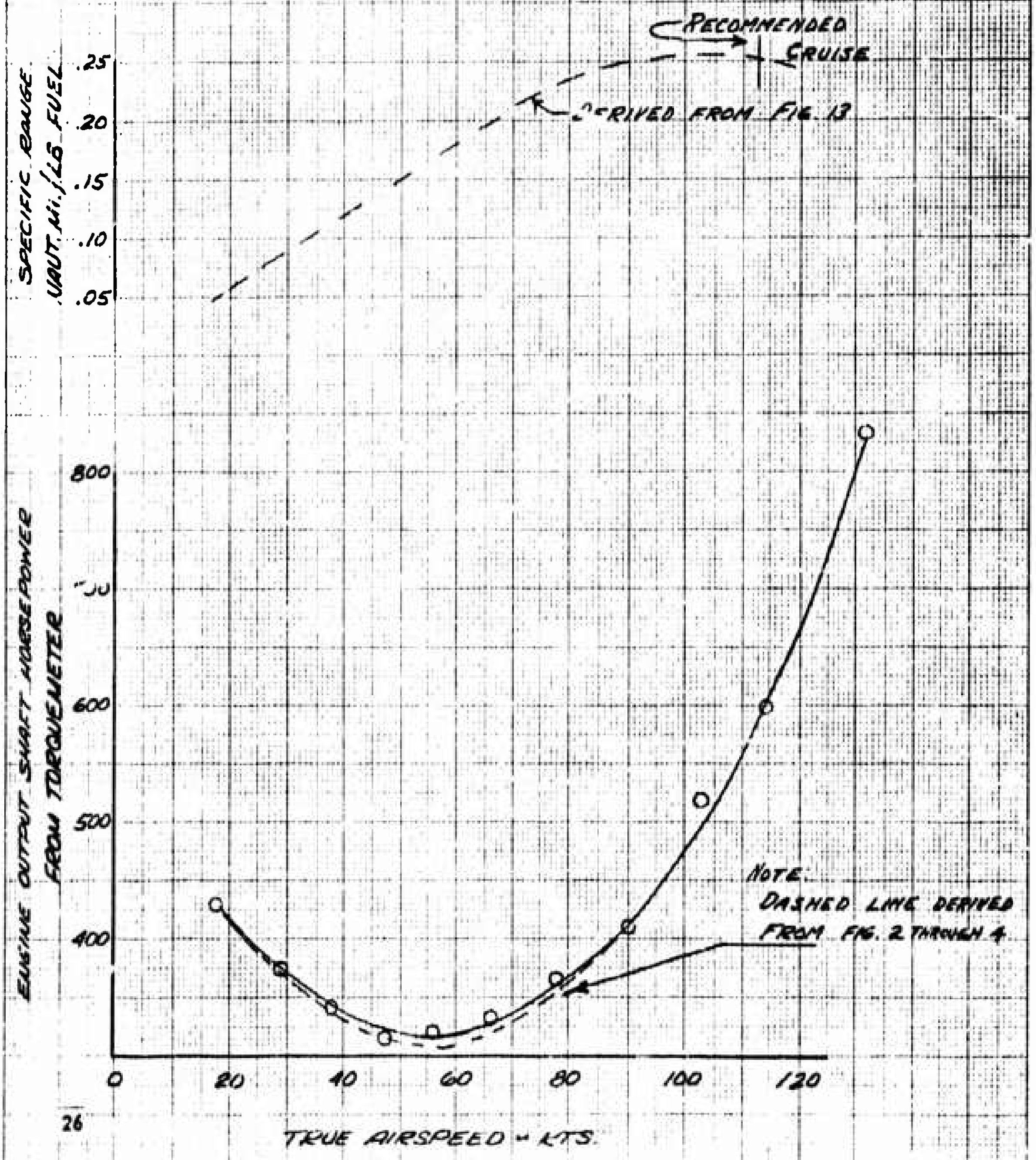
FIGURE No. 5
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE
YHU-1B
S/N 58-2078
NOTE:
POINTS ARE TAKEN
FROM FAIRED CURVES
FIGS. 6 THROUGH 10
μ = .27
μ = .26
μ = .24
$C_P \times 10^5 = \frac{550\, SHP}{\rho A (\Omega R)^3} \times 10^5$
$C_T \times 10^4 = \frac{W}{\rho A (\Omega R)^2} \times 10^4$

FIG. NO. 6

LEVEL FLIGHT PERFORMANCE

YHU-1B	S/N 58-2078
GROSS WEIGHT	5600 LB
DENSITY ALT.	4000 FT.
ROTOR RPM	323
C_T	0.00316

M.D. C.G.



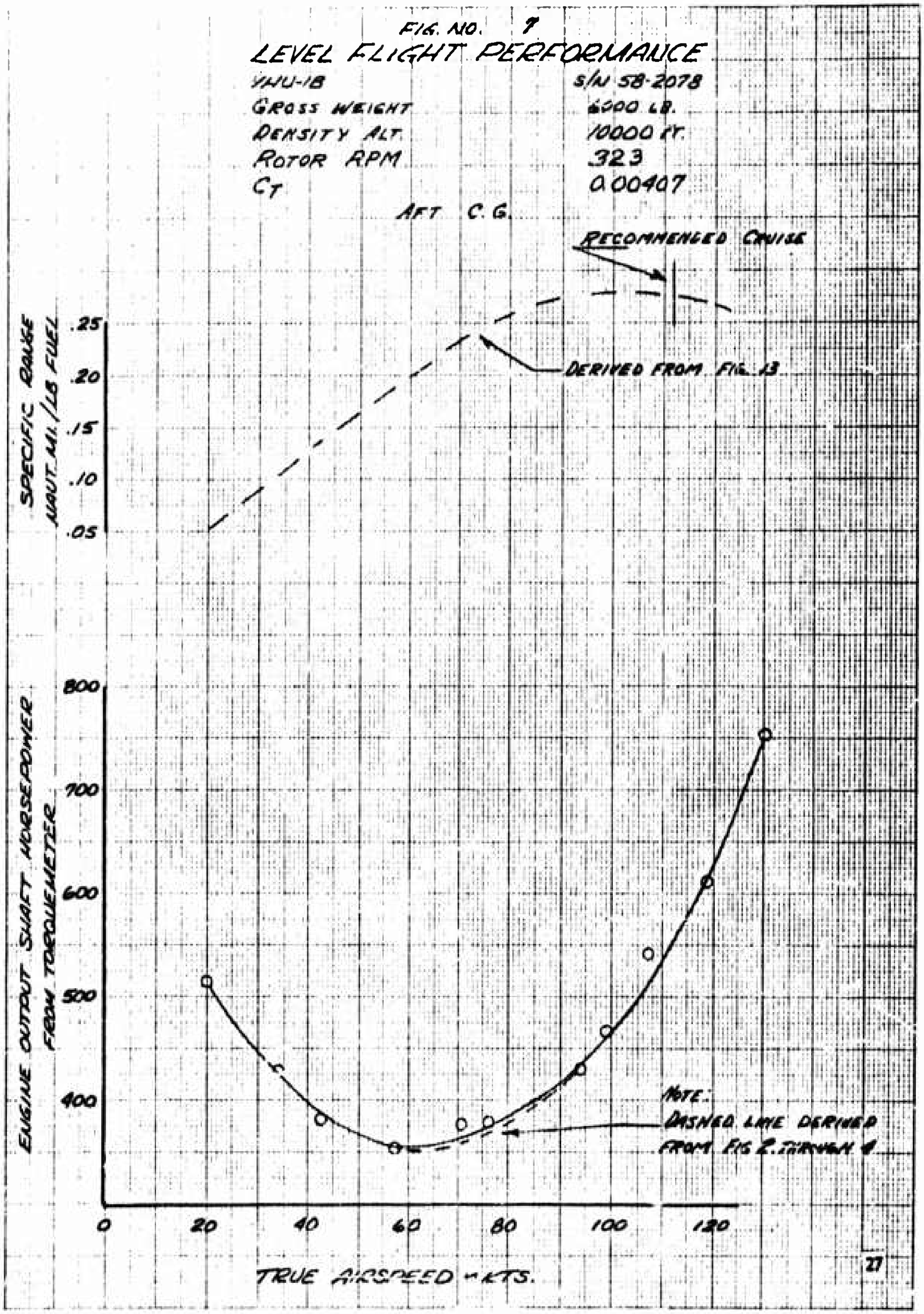


FIG. NO. 7
LEVEL FLIGHT PERFORMANCE
YHU-1B
S/N 58-2078
GROSS WEIGHT
6000 LB.
DENSITY ALT.
10000 FT.
ROTOR RPM
323
C_T
0.00407
AFT C.G.
RECOMMENDED CRUISE
DERIVED FROM FIG. 13
SPECIFIC RANGE
NAUT. MI./LB FUEL
.25
.20
.15
.10
.05
ENGINE OUTPUT SHAFT HORSEPOWER
FROM TORQUEMETER
800
700
600
500
400
NOTE:
DASHED LINE DERIVED
FROM FIG 2 THROUGH 4
0
20
40
60
80
100
120
TRUE AIRSPEED ~ KTS.

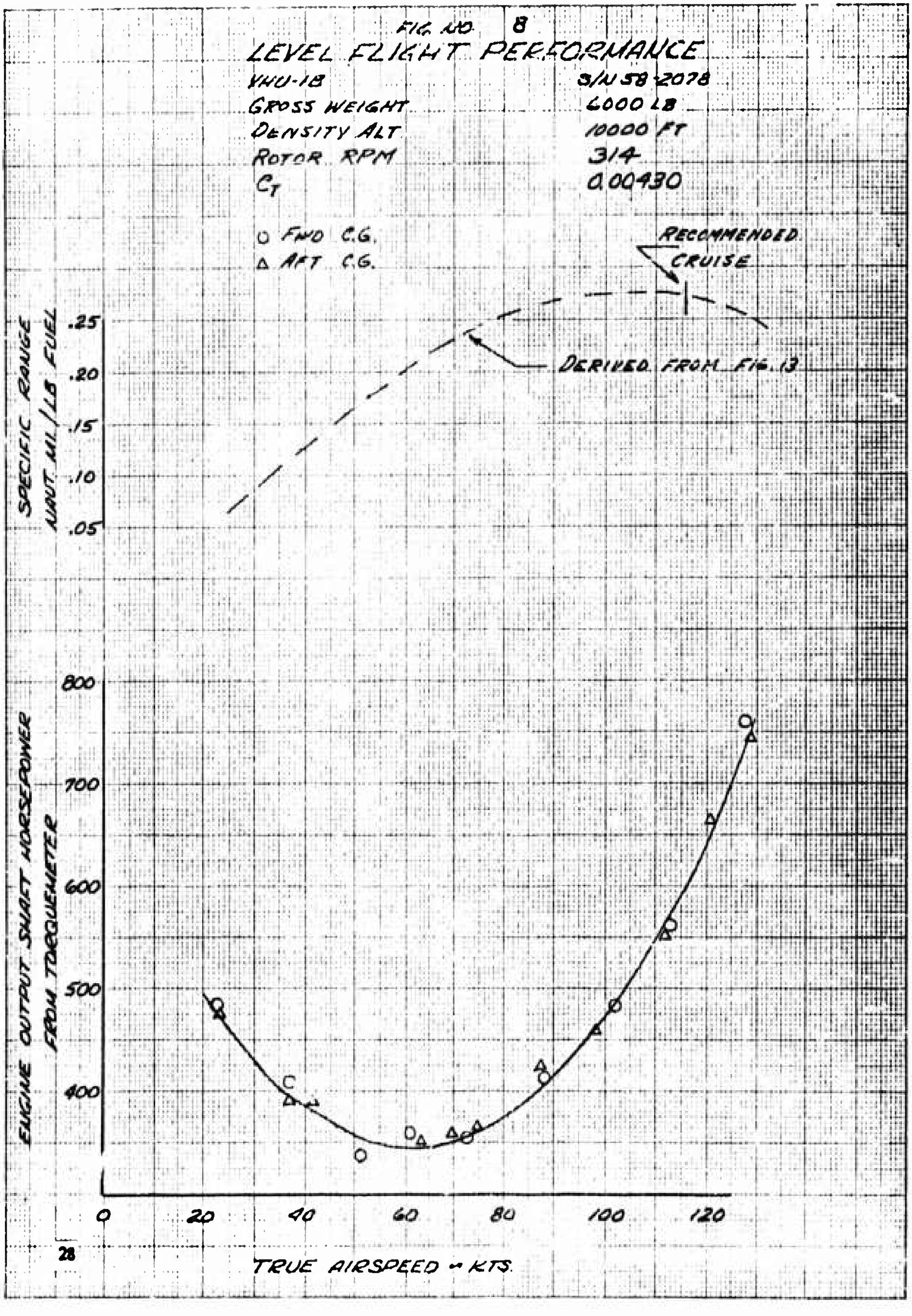


FIG. NO. 8
LEVEL FLIGHT PERFORMANCE
YHU-1B
S/N 58-2078
GROSS WEIGHT
6000 LB
DENSITY ALT
10000 FT
ROTOR RPM
314
C_T
0.00430
○ FWD C.G.
△ AFT C.G.
RECOMMENDED CRUISE
DERIVED FROM FIG. 13
SPECIFIC RANGE
NAUT. MI./LB FUEL
.25
.20
.15
.10
.05
ENGINE OUTPUT SHAFT HORSEPOWER
FROM TORQUEMETER
800
700
600
500
400
0
20
40
60
80
100
120
TRUE AIRSPEED ~ KTS.

FIG. NO. 9

LEVEL FLIGHT PERFORMANCE

YHU-1B	S/N 58-2078
GROSS WEIGHT	7300 LB
DENSITY ALT	10000 FT
ROTOR RPM	323
C_T	0.00489

MID C.G.

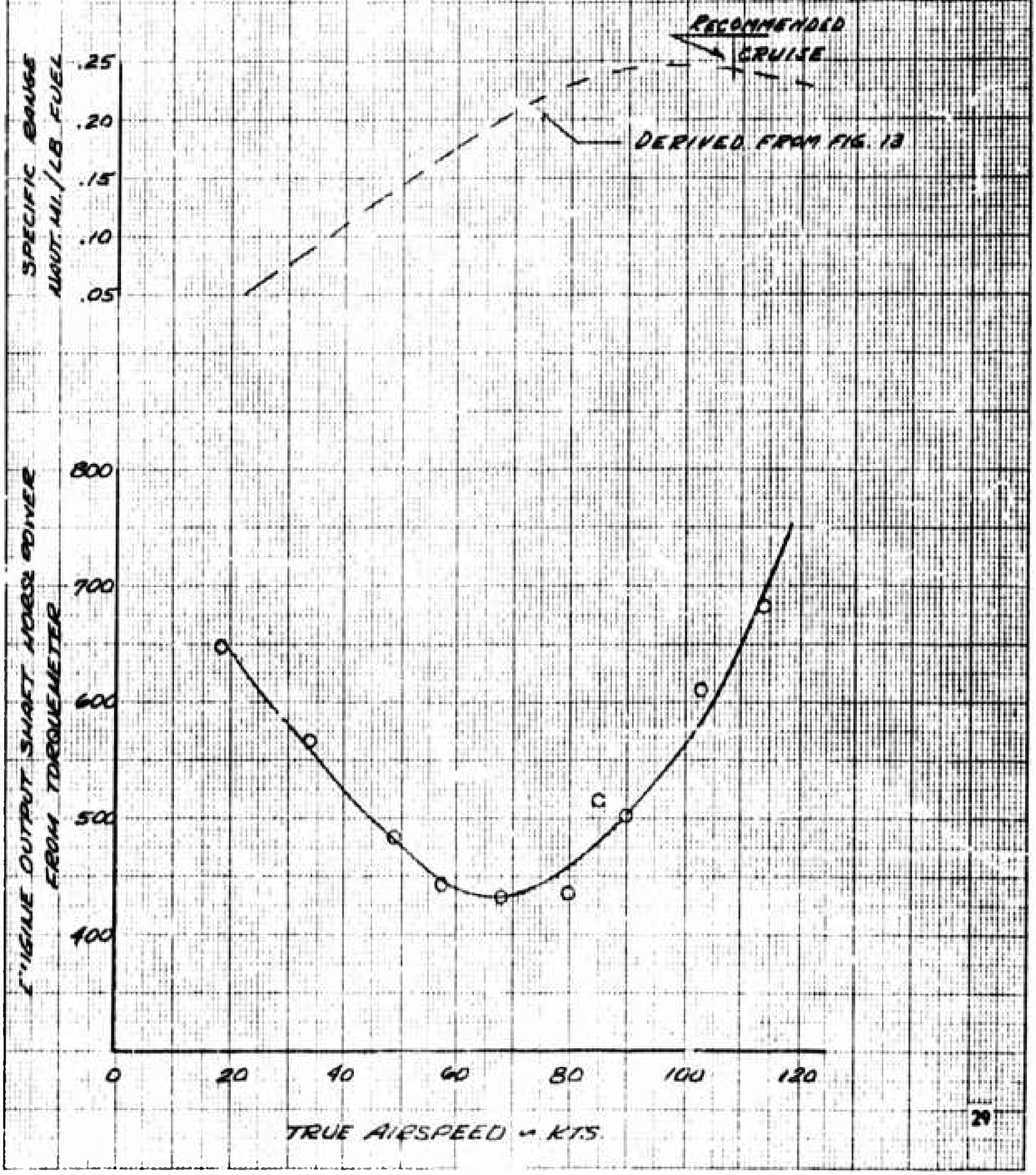


FIG. NO. 10

LEVEL FLIGHT PERFORMANCE

YHU-1B S/N 58-2078

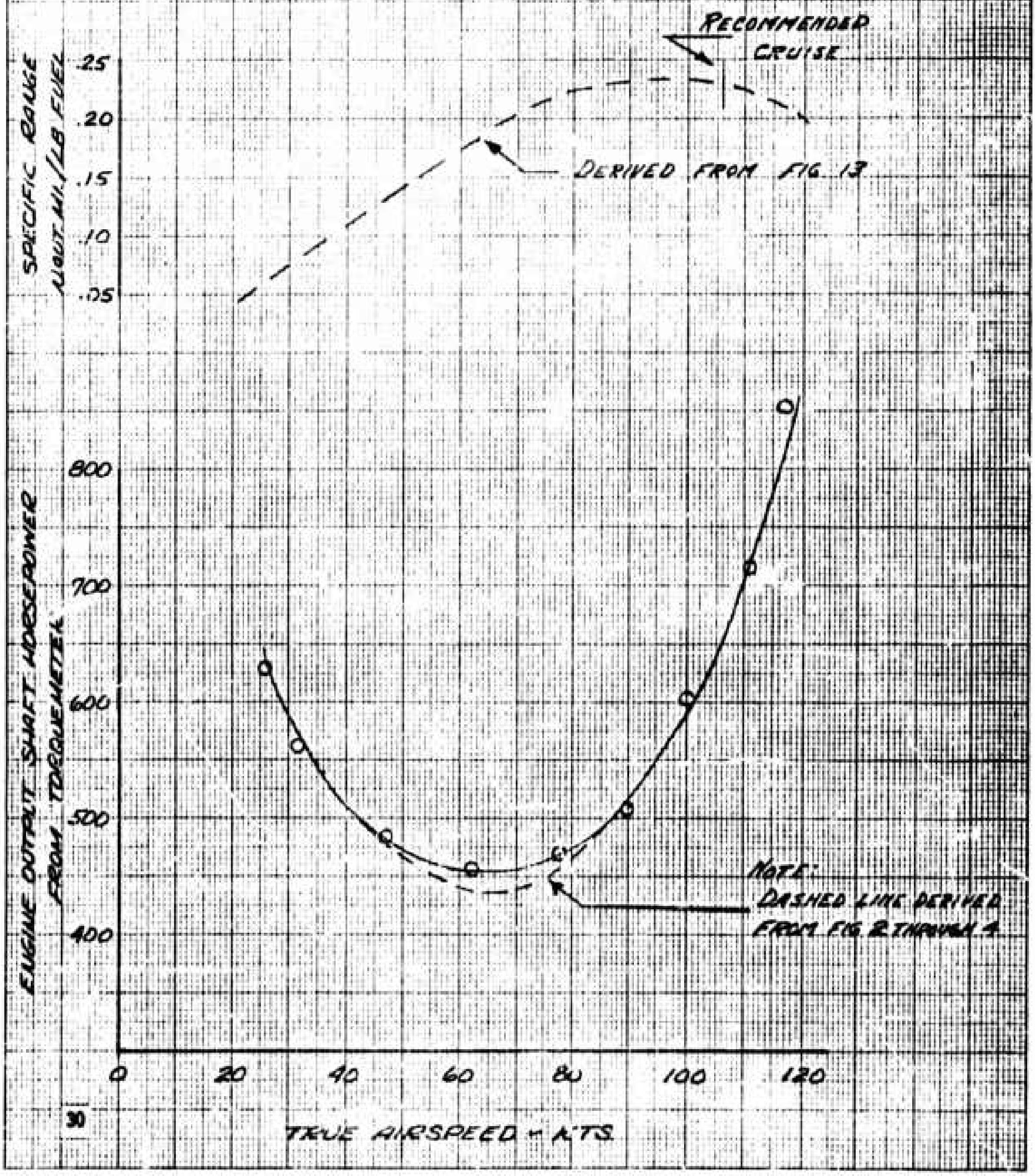
GROSS WEIGHT 7200 LB

DENSITY ALT 10000 FT.

ROTOR RPM 314

C_T 0.00515

MID C.G.



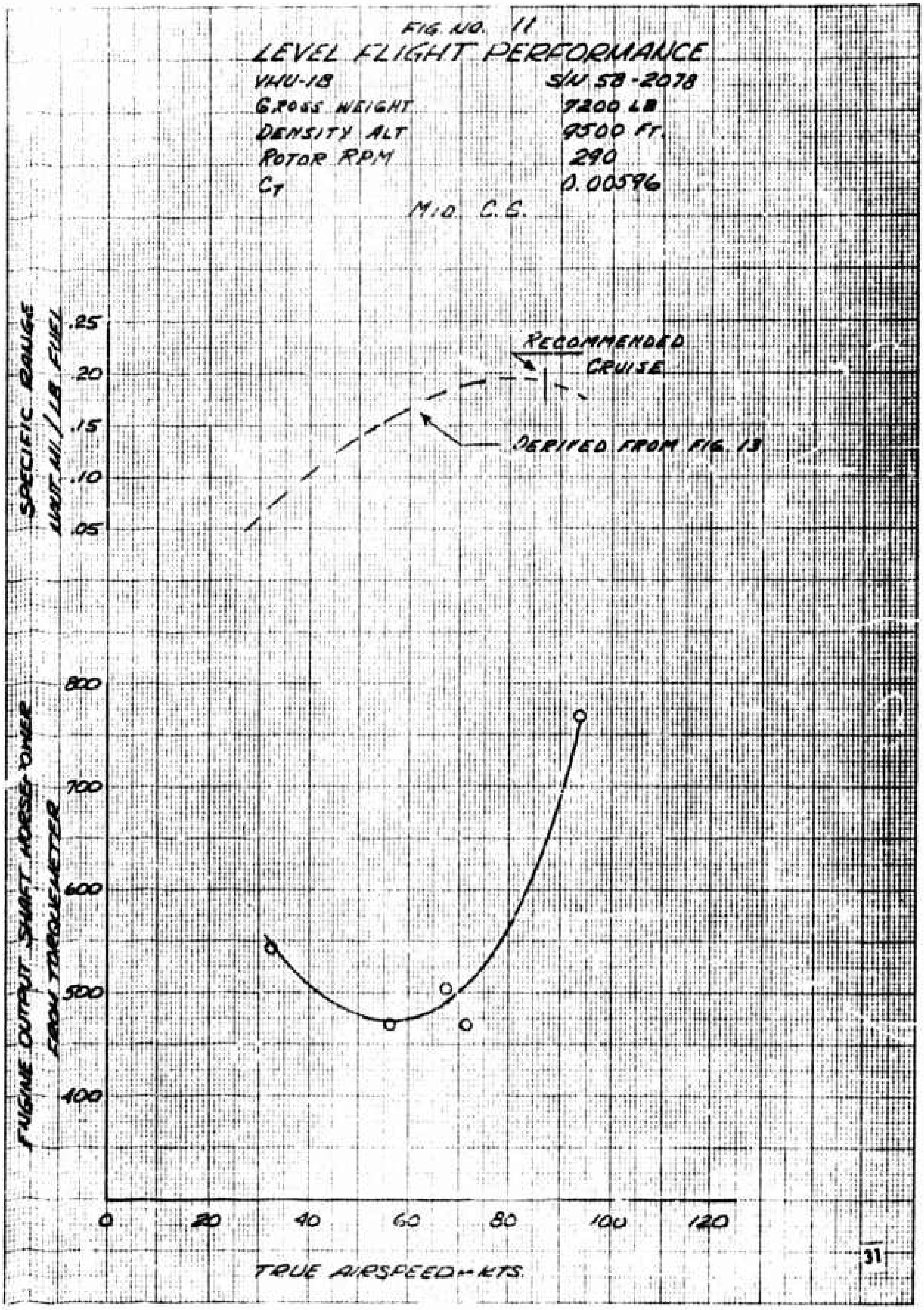


FIG. NO. 11
LEVEL FLIGHT PERFORMANCE
YHU-18
S/N 58-2078
GROSS WEIGHT
7200 LB
DENSITY ALT
9500 FT.
ROTOR RPM
290
C_T
0.00596
MID. C.G.
SPECIFIC RANGE
UNIT MI / LB FUEL
.25
.20
.15
.10
.05
RECOMMENDED CRUISE
DERIVED FROM FIG. 13
ENGINE OUTPUT SHAFT HORSEPOWER
FROM TORQUEMETER
800
700
600
500
400
0
20
40
60
80
100
120
TRUE AIRSPEED ~ KTS.

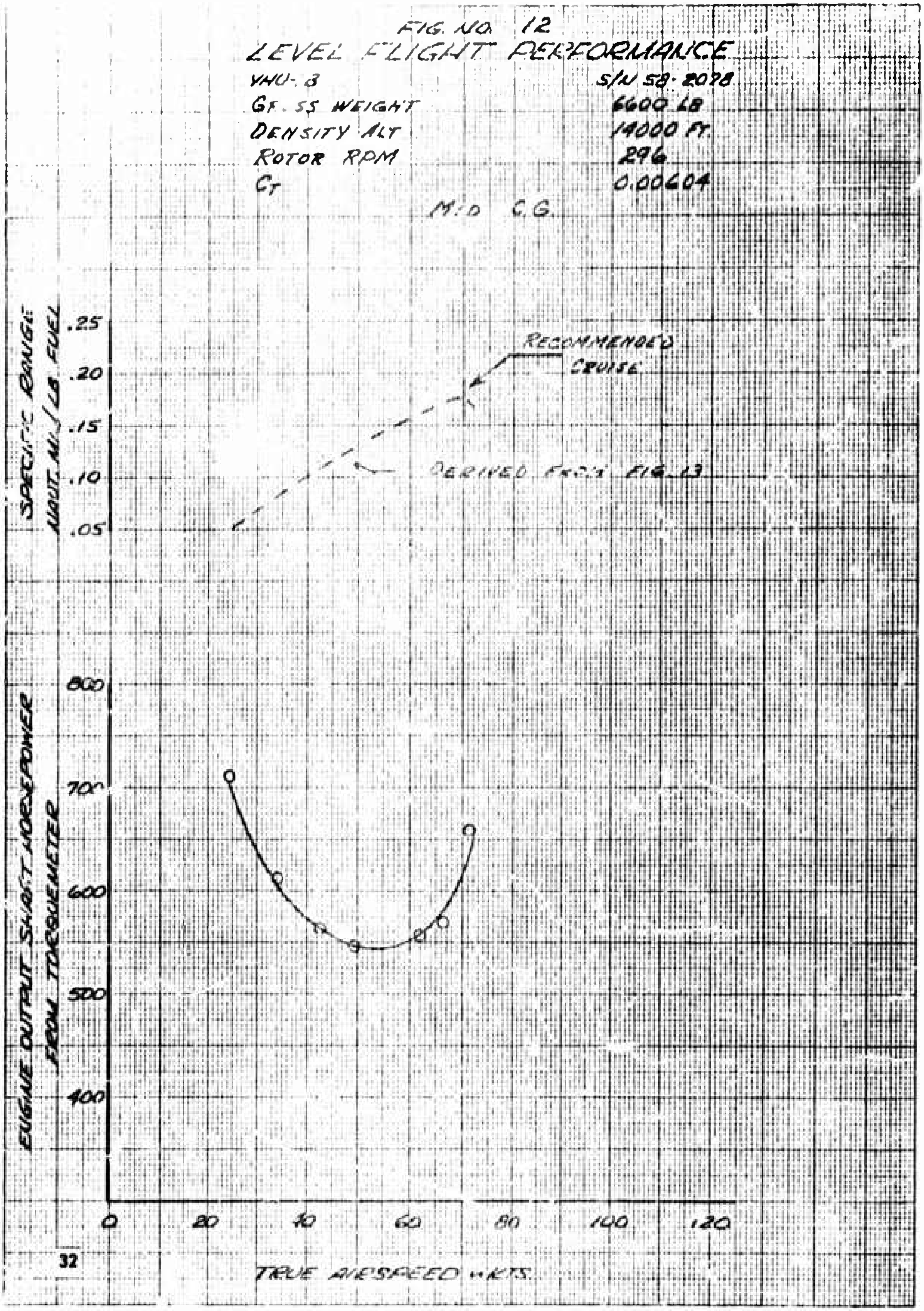


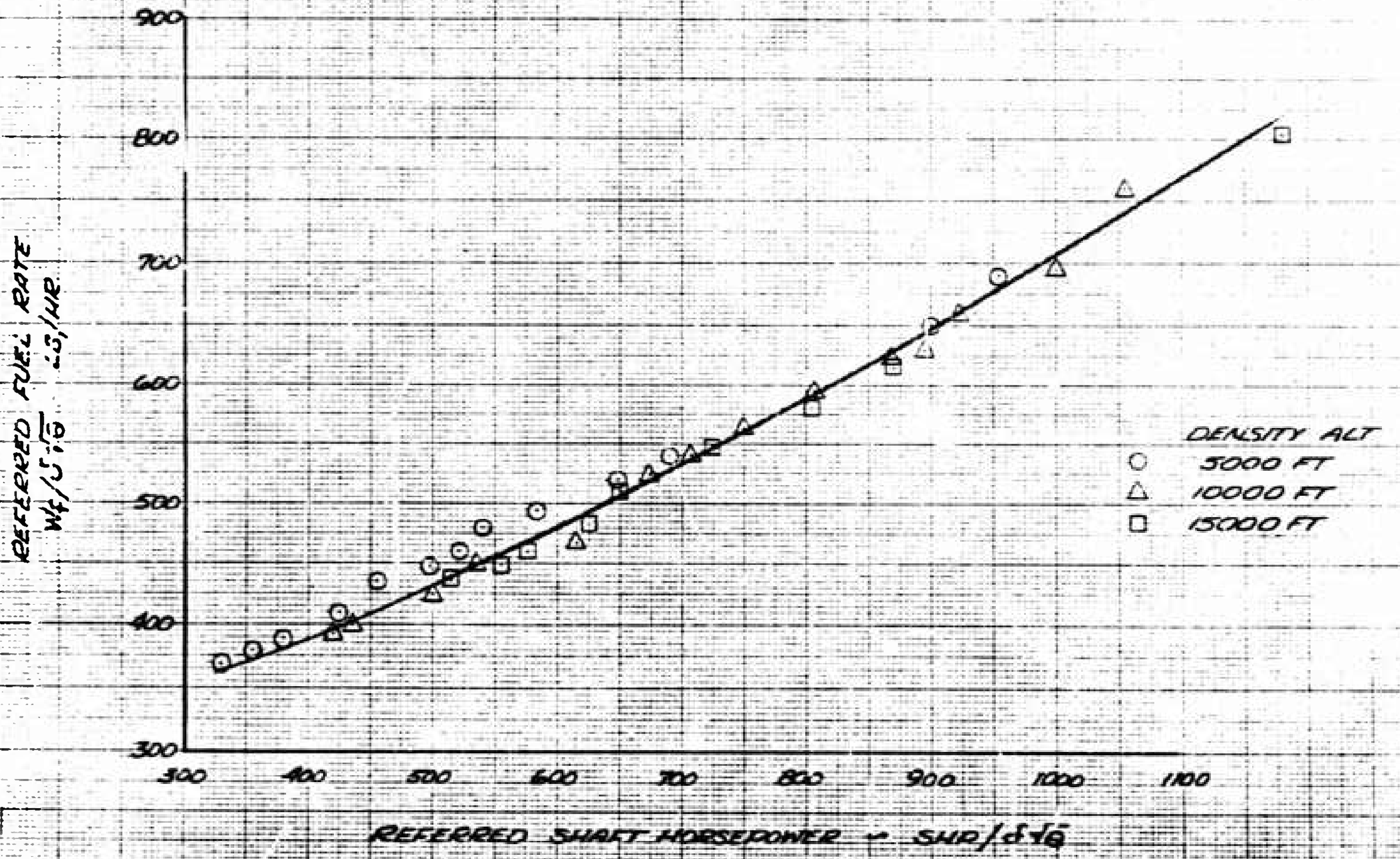
FIG. NO. 12
LEVEL FLIGHT PERFORMANCE
YHU-1B
S/N 58-2078
GROSS WEIGHT
6600 LB
DENSITY ALT
14000 FT.
ROTOR RPM
296
C_T
0.00604
MID C.G.
RECOMMENDED CRUISE
DERIVED FROM FIG. 13
SPECIFIC RANGE NAUT. MI./LB. FUEL
.25
.20
.15
.10
.05
ENGINE OUTPUT SHAFT HORSEPOWER FROM TORQUEMETER
800
700
600
500
400
0
20
40
60
80
100
120
TRUE AIRSPEED ~ KTS.

FIG. NO. 13

ENGINE CHARACTERISTICS

YHU-1B S/N 58-2078

ENGINE T53-L5 S/N LE03007



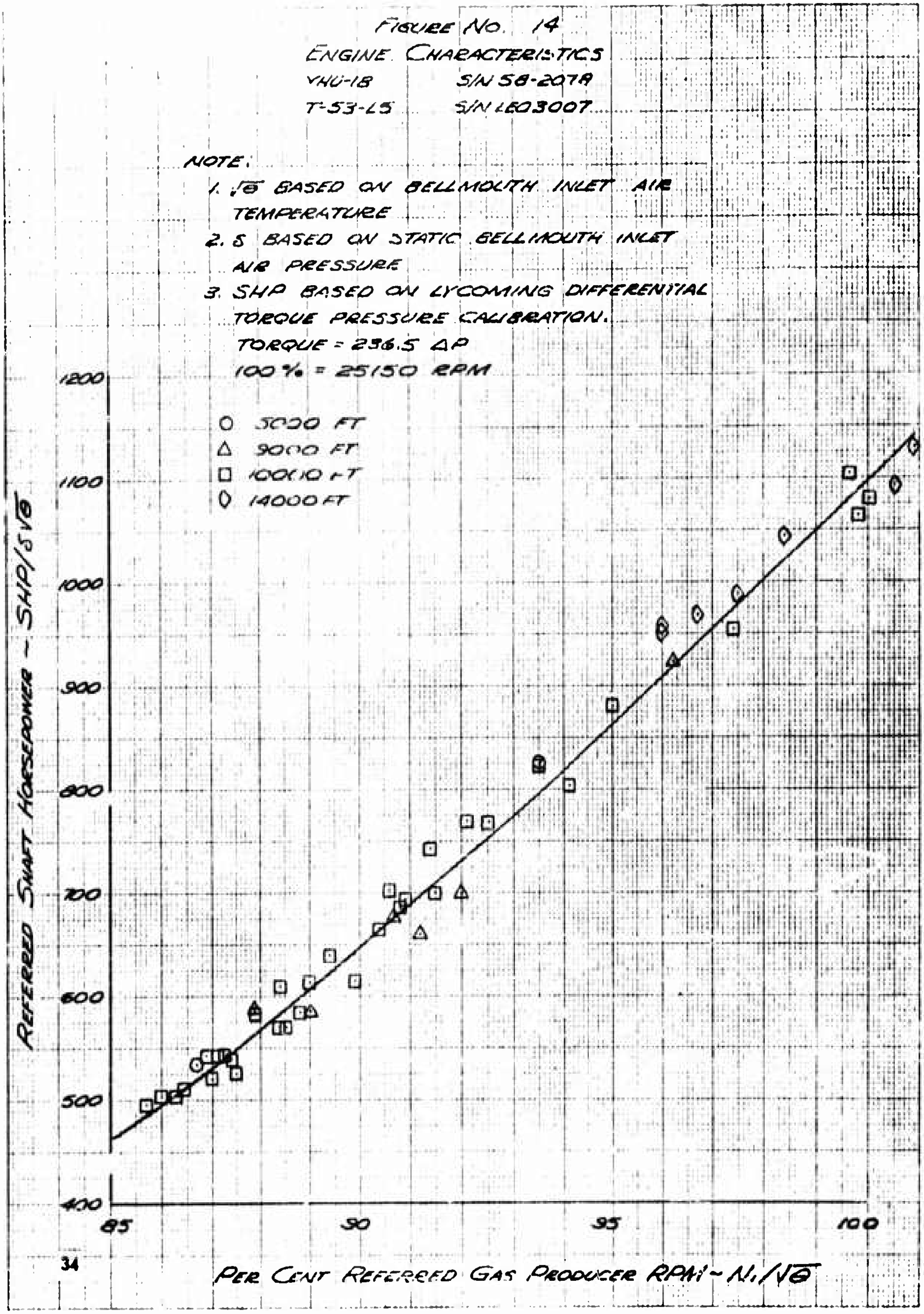


FIGURE NO. 14
ENGINE CHARACTERISTICS
YHU-1B S/N 58-2079
T-53-L5 S/N LE03007
NOTE:
1. √θ BASED ON BELLMOUTH INLET AIR TEMPERATURE
2. δ BASED ON STATIC BELLMOUTH INLET AIR PRESSURE
3. SHP BASED ON LYCOMING DIFFERENTIAL TORQUE PRESSURE CALIBRATION.
TORQUE = 236.5 ΔP
100% = 25150 RPM
○ 5000 FT
△ 9000 FT
□ 10000 FT
◇ 14000 FT
REFERRED SHAFT HORSEPOWER ~ SHP/δ√θ
400
500
600
700
800
900
1000
1100
1200
85
90
95
100
PER CENT REFERRED GAS PRODUCER RPM ~ N₁/√θ

FIG. NO. 15

SHAFT HORSEPOWER AVAILABLE

YHU-1B S/N 58-2078

ENGINE T53-L5 S/N LE03007

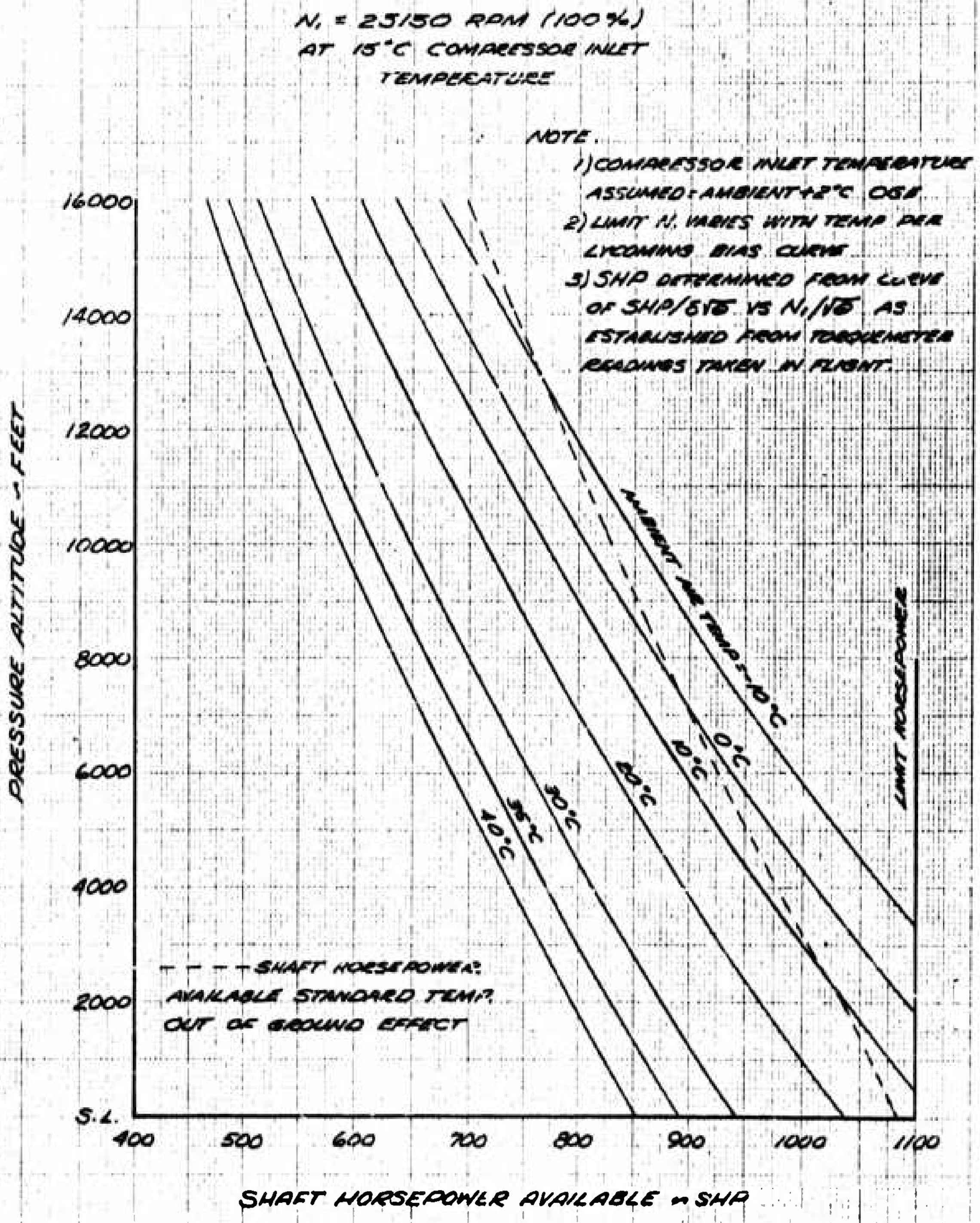


FIG. NO. 15

SHAFT HORSEPOWER AVAILABLE

YHU-1B S/N 58-2078

ENGINE T53-L5 S/N LE03007

N_1 = 25150 RPM (100%)
AT 15°C COMPRESSOR INLET
TEMPERATURE

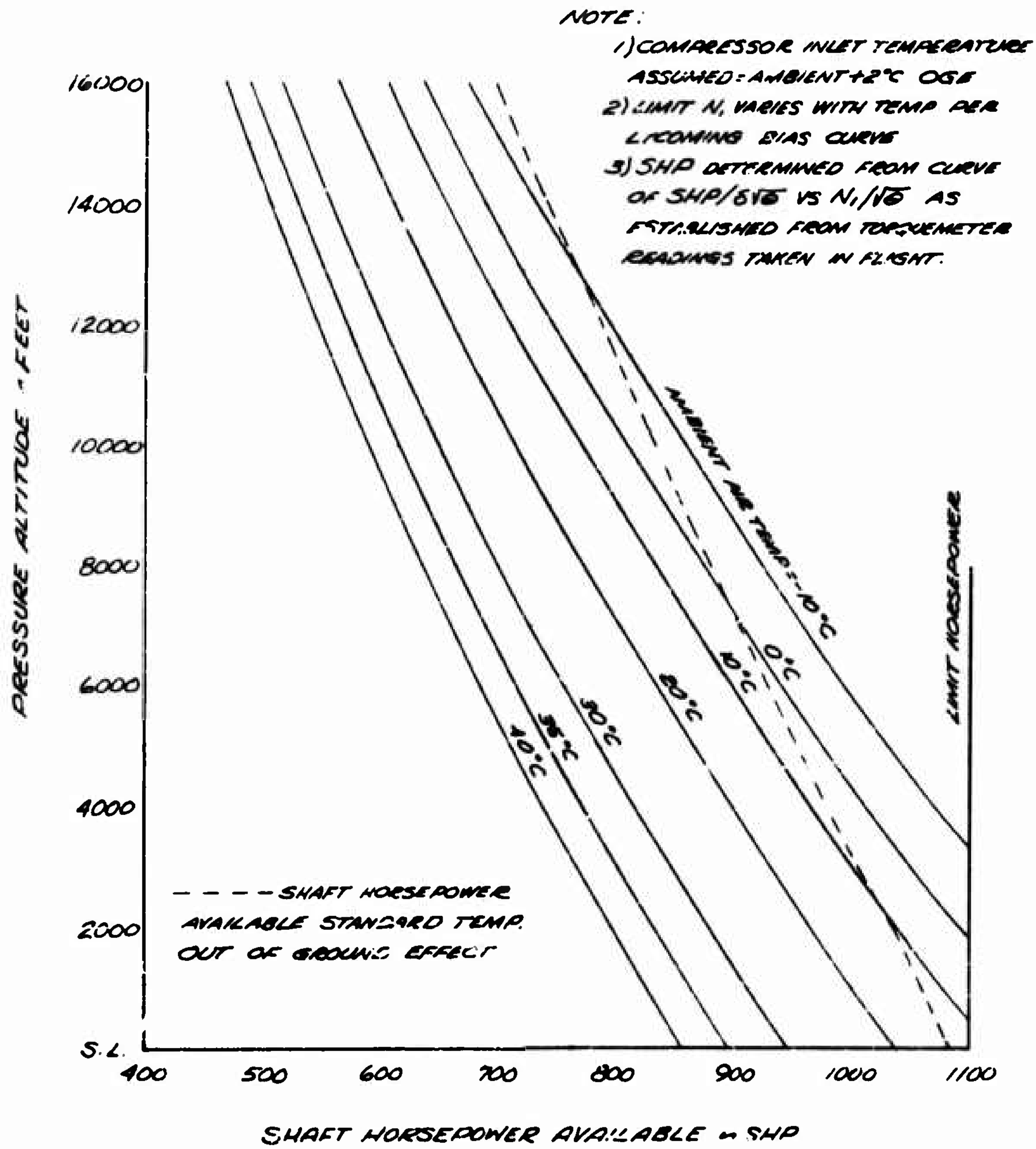
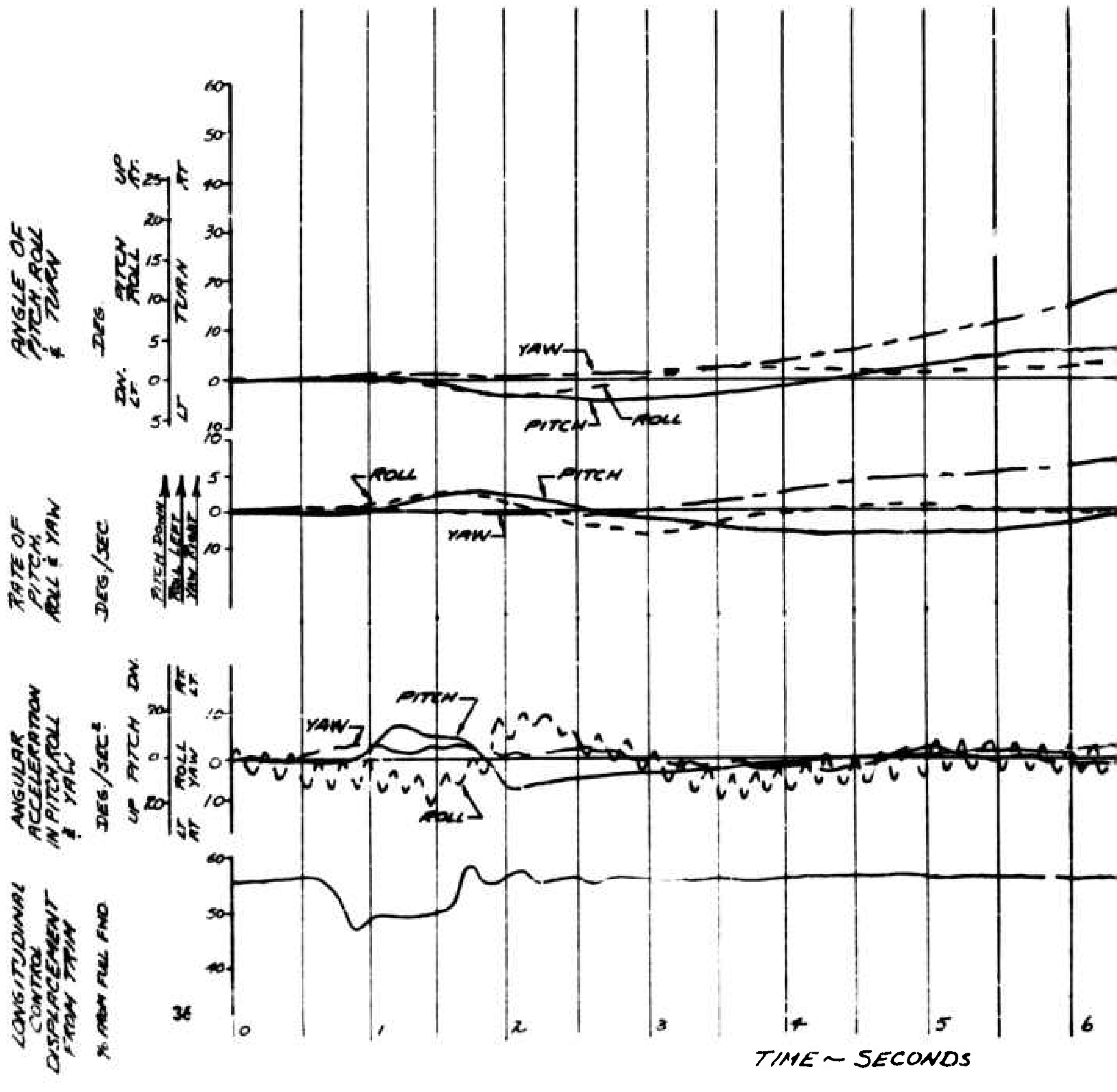


FIGURE NO. 16

1

RESPONSE TO A FORWARD LONGITUDINAL PULSE
YHU-1B SN 58-2078
C.G. LOCATION ~ 131.0 (MID) DENSITY ALTITUDE ~ 3000 FT.
ROTOR SPEED ~ 323 GROSS WEIGHT ~ 6600 LB.
HOVER



SE
078
3000 FT.
0 LB.

2

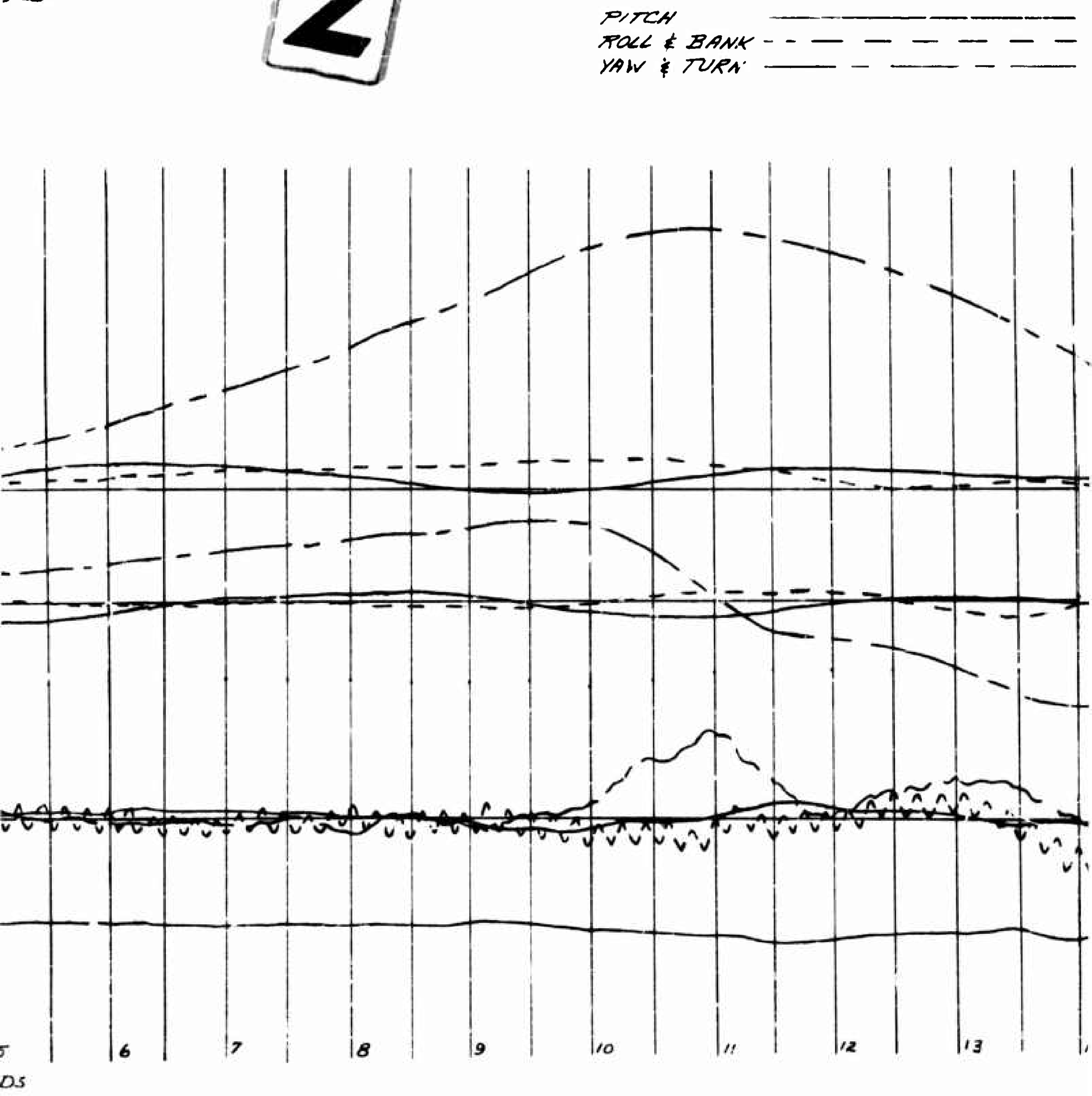


FIGURE No. 17

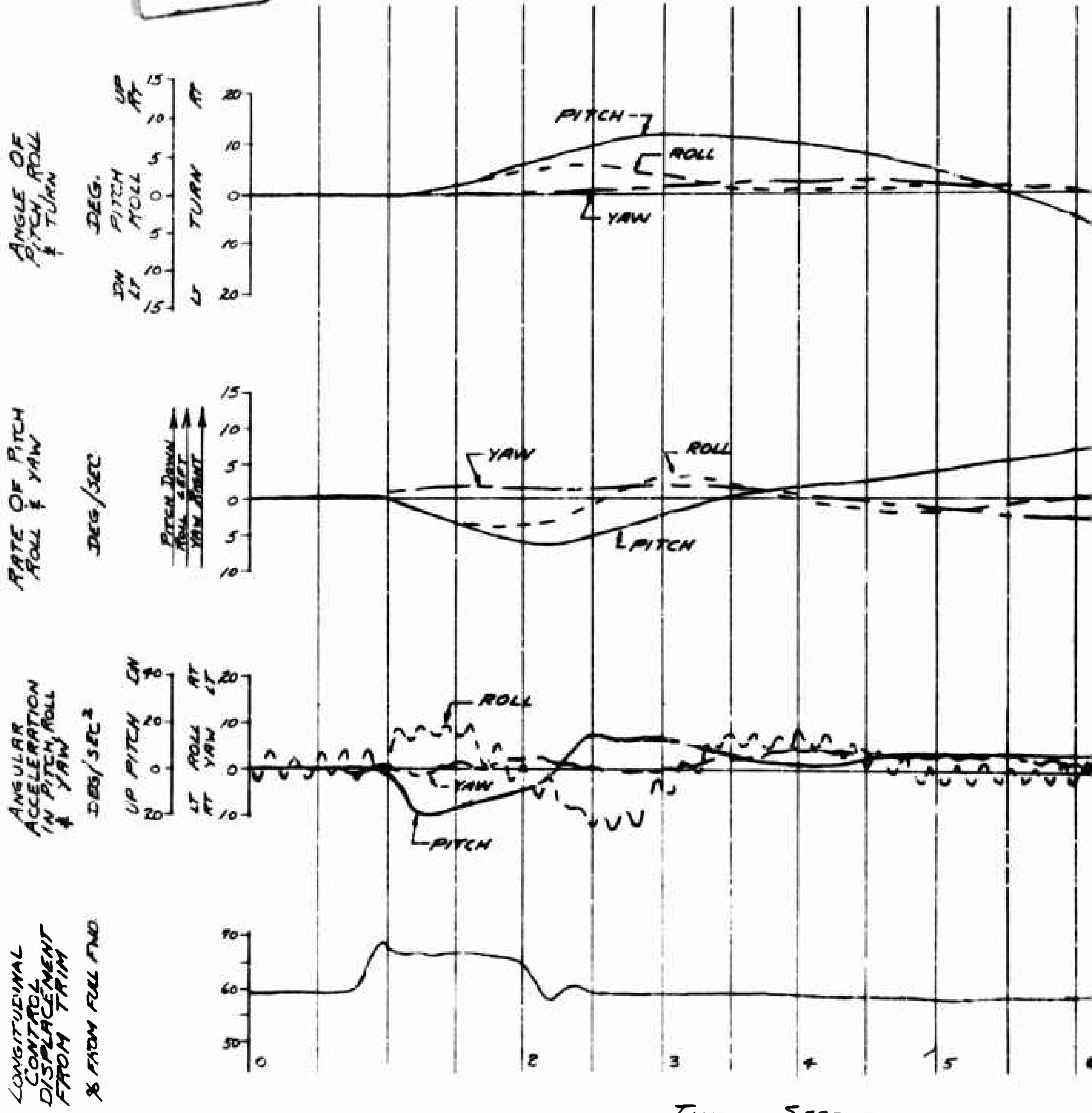
RESPONSE TO AN AFT LONGITUDINAL PULSE

YHU-1B S/N 58-2078

C.G. LOCATION ~ 131.0 (MID) DENSITY ALTITUDE ~ 3000 FT.

ROTOR SPEED ~ 323 GROSS WEIGHT ~ 6600 LB.

HOVER



2

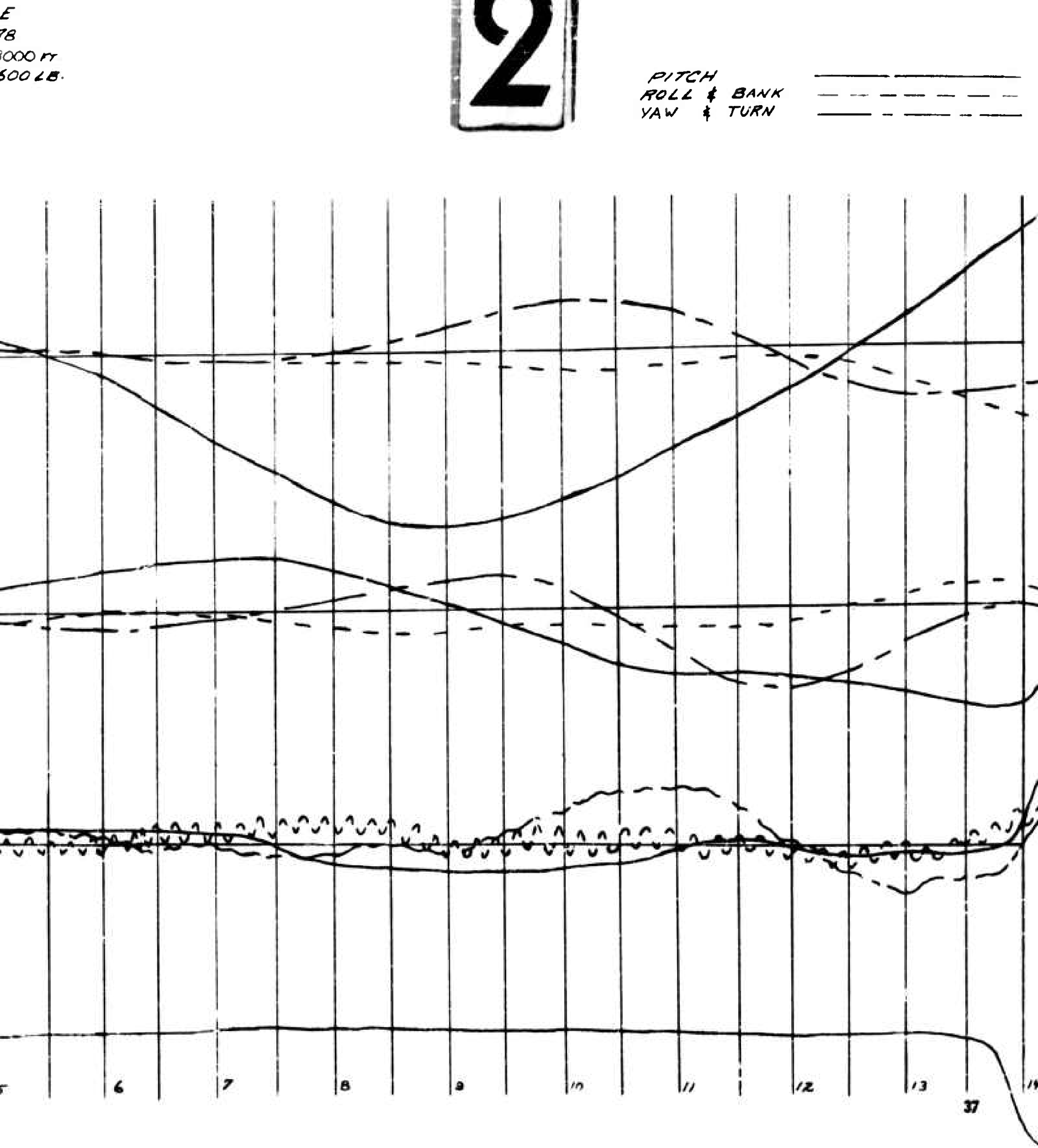


FIGURE No. 18

RESPONSE TO A RIGHT LATERAL PULSE

YHU-1B S/N 58-2078

C.G. LOCATION ~ 131.0 (MID)
ROTOR SPEED ~ 323

DENSITY ALTITUDE ~ 3000 FT.
GROSS WEIGHT ~ 6600 LB.

HOVER

PITCH
ROLL & BANK
YAW & TURN

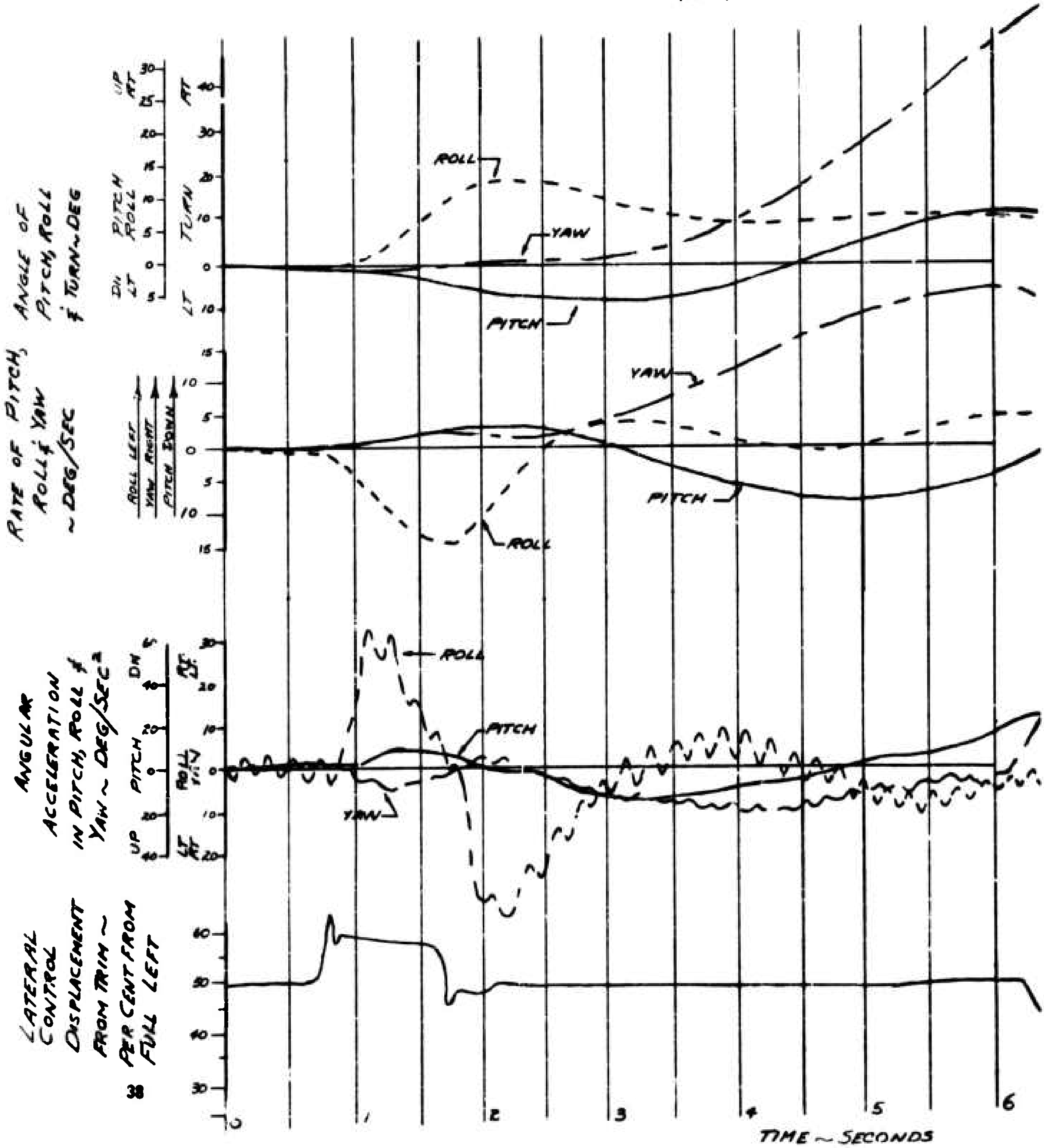


FIGURE NO. 19

RESPONSE TO A LEFT LATERAL PULSE

YHU-1B S/N 58-2078

C.G. LOCATION ~ 131.0 (MID) DENSITY ALT. ~ 3000 FT.

ROTOR SPEED ~ 323 GROSS WEIGHT ~ 6600 LB.

HOVER

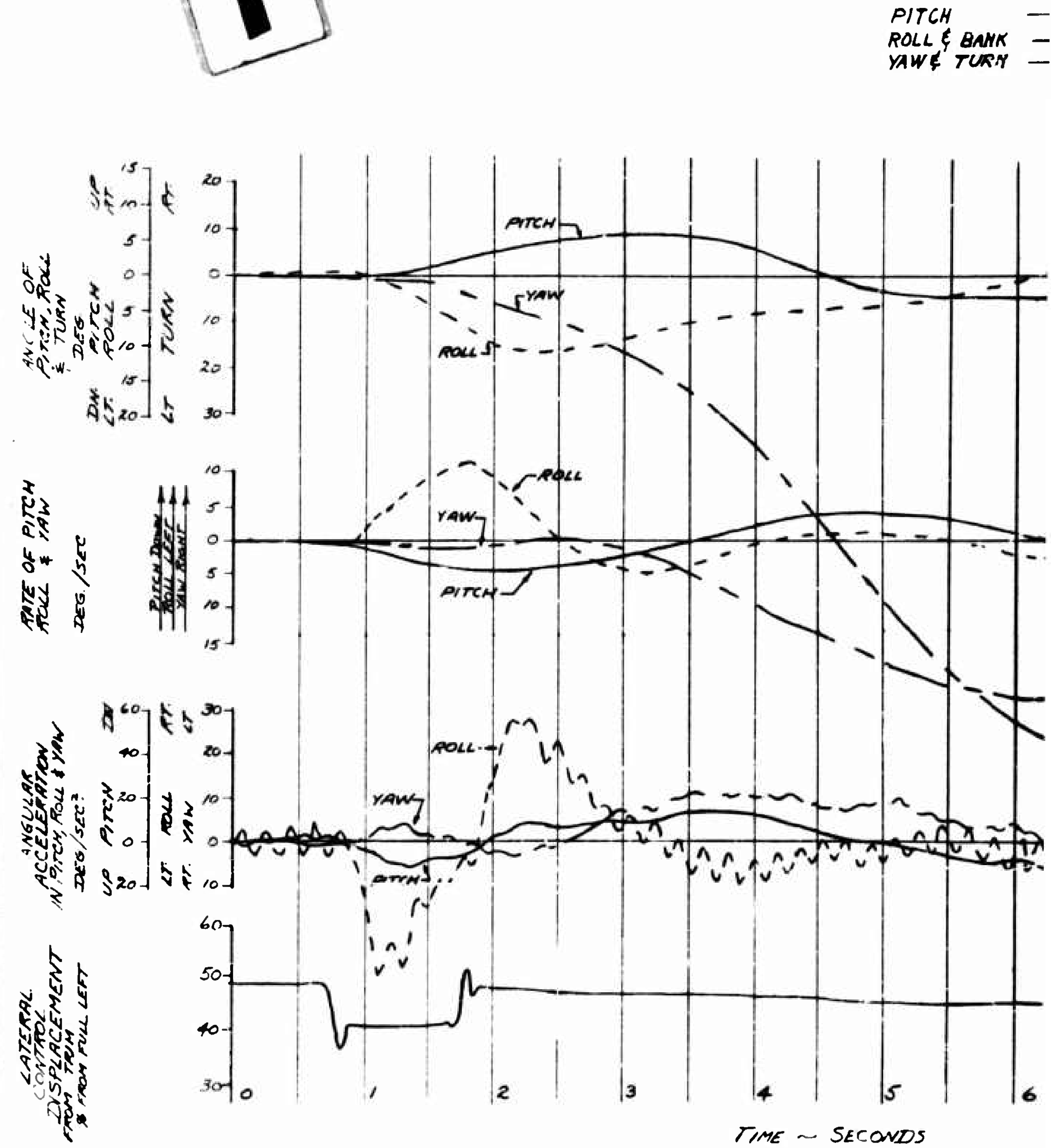
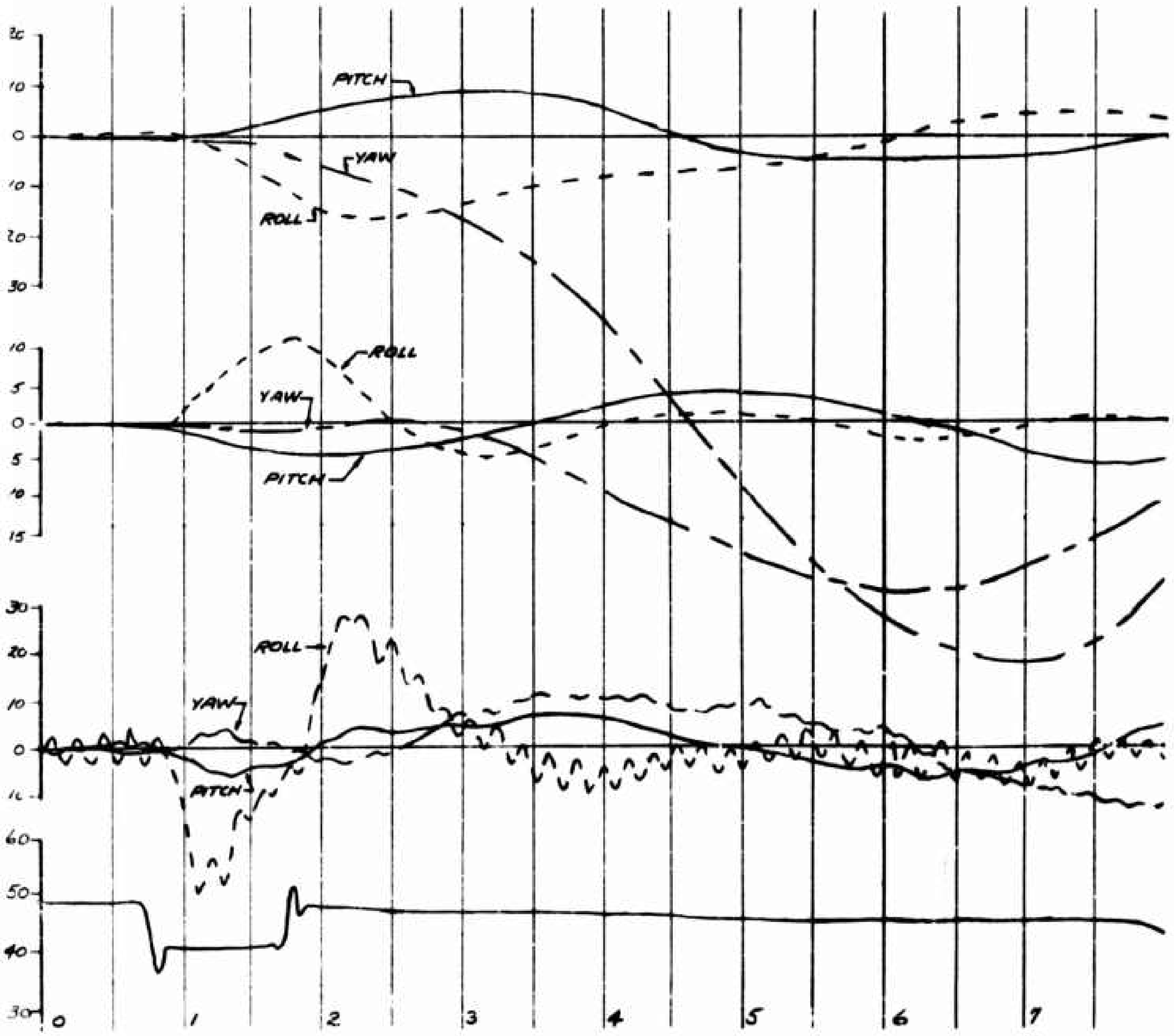


FIGURE NO. 19

RESPONSE TO A LEFT LATERAL PULSE
YHU-1B S/N 58-2078
C.G. LOCATION ~ 131.0 (MID) DENSITY ALT. ~ 3000 FT.
ROTOR SPEED ~ 323 GROSS WEIGHT ~ 6600 LB.
HOVER

2

PITCH ——————
ROLL & BANK – – – – – –
YAW & TURN —— – —— – ——



TIME ~ SECONDS

FIGURE NO. 20

RESPONSE TO A RIGHT DIRECTIONAL PULSE

YHU-1B S/N 58-2078

CG LOCATION ~ 131.0 (MID) DENSITY ALTITUDE ~ 3000 FT.

ROTOR SPEED ~ 323 GROSS WEIGHT ~ 6600 LB.

HOVER

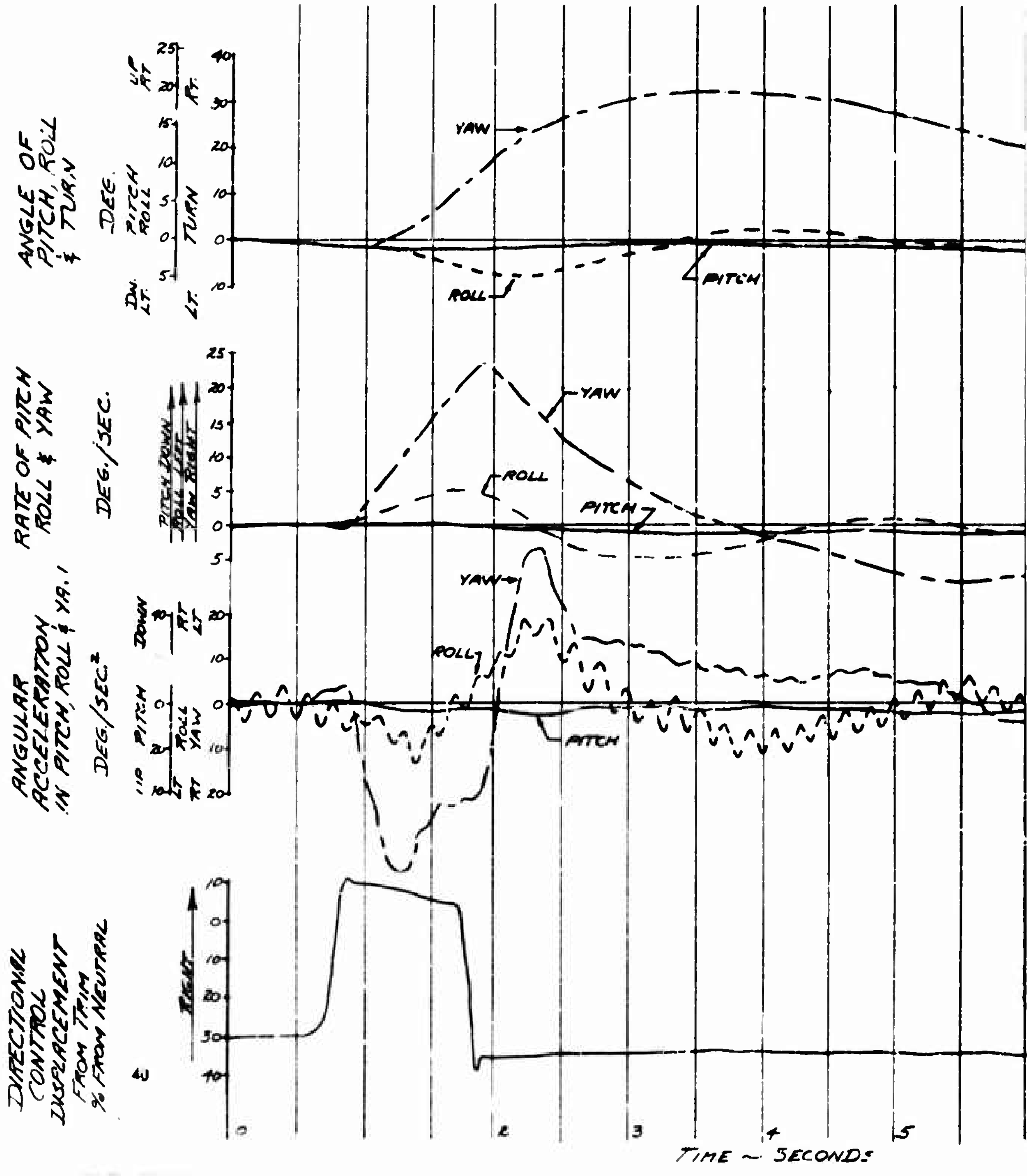


FIGURE NO. 20

RESPONSE TO A RIGHT DIRECTIONAL PULSE

YHU-1B S/N 58-2078

CG LOCATION ~ 131.0 (MID) DENSITY ALTITUDE ~ 3000 FT.

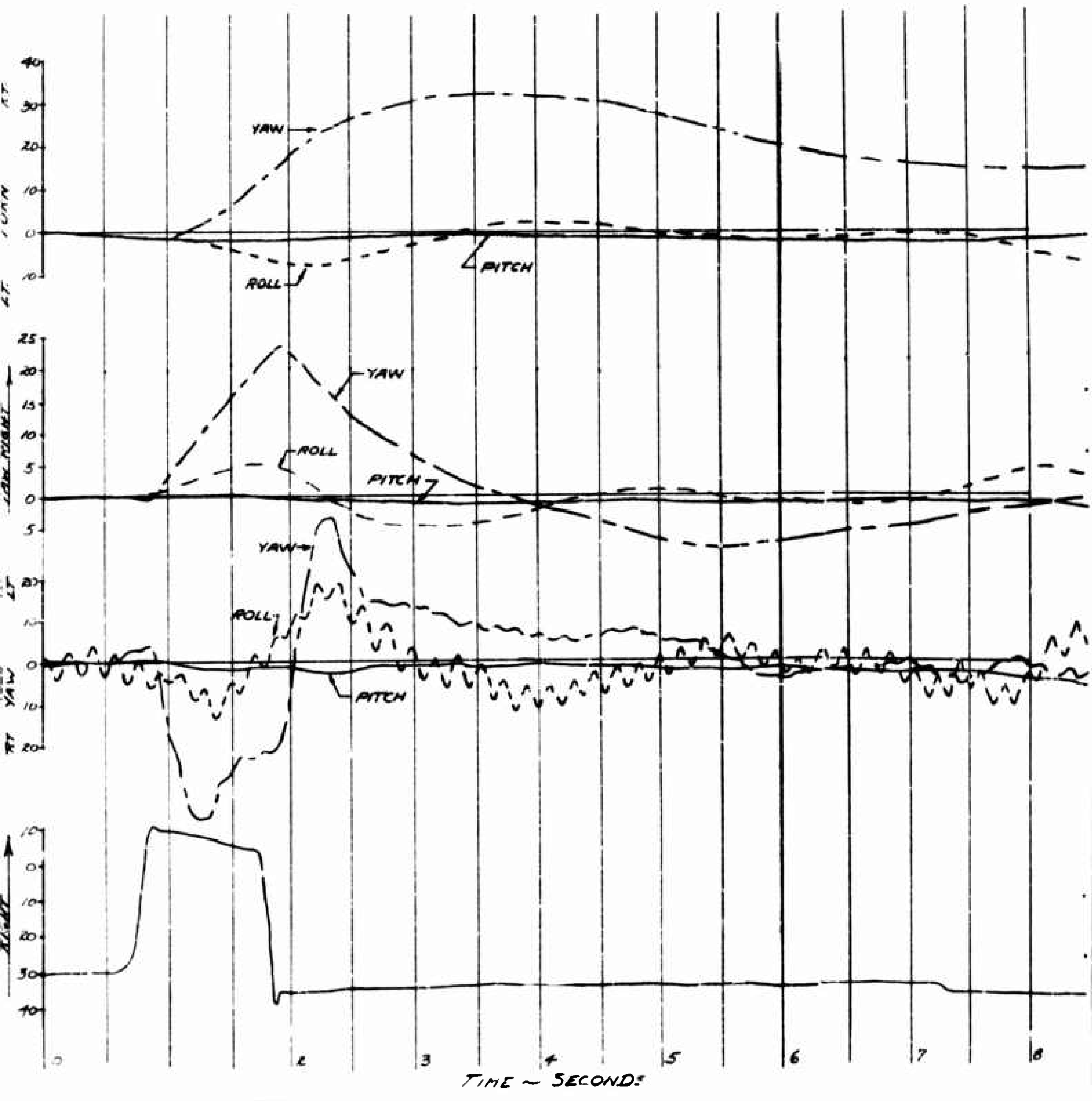
ROTOR SPEED ~ 323 GROSS WEIGHT ~ 6600 LB.

HOVER

PITCH ————

ROLL & BANK — — —

YAW & TURN — - —



1

FIGURE NO 21

RESPONSE TO A LEFT DIRECTIONAL PULSE

HU-1B S/N 58-2078

CG. LOCATION -- 1310 (MID) DENSITY ALTITUDE~

ROTOR SPEED ~ 323 GROSS WEIGHT ~ 660

HOVER

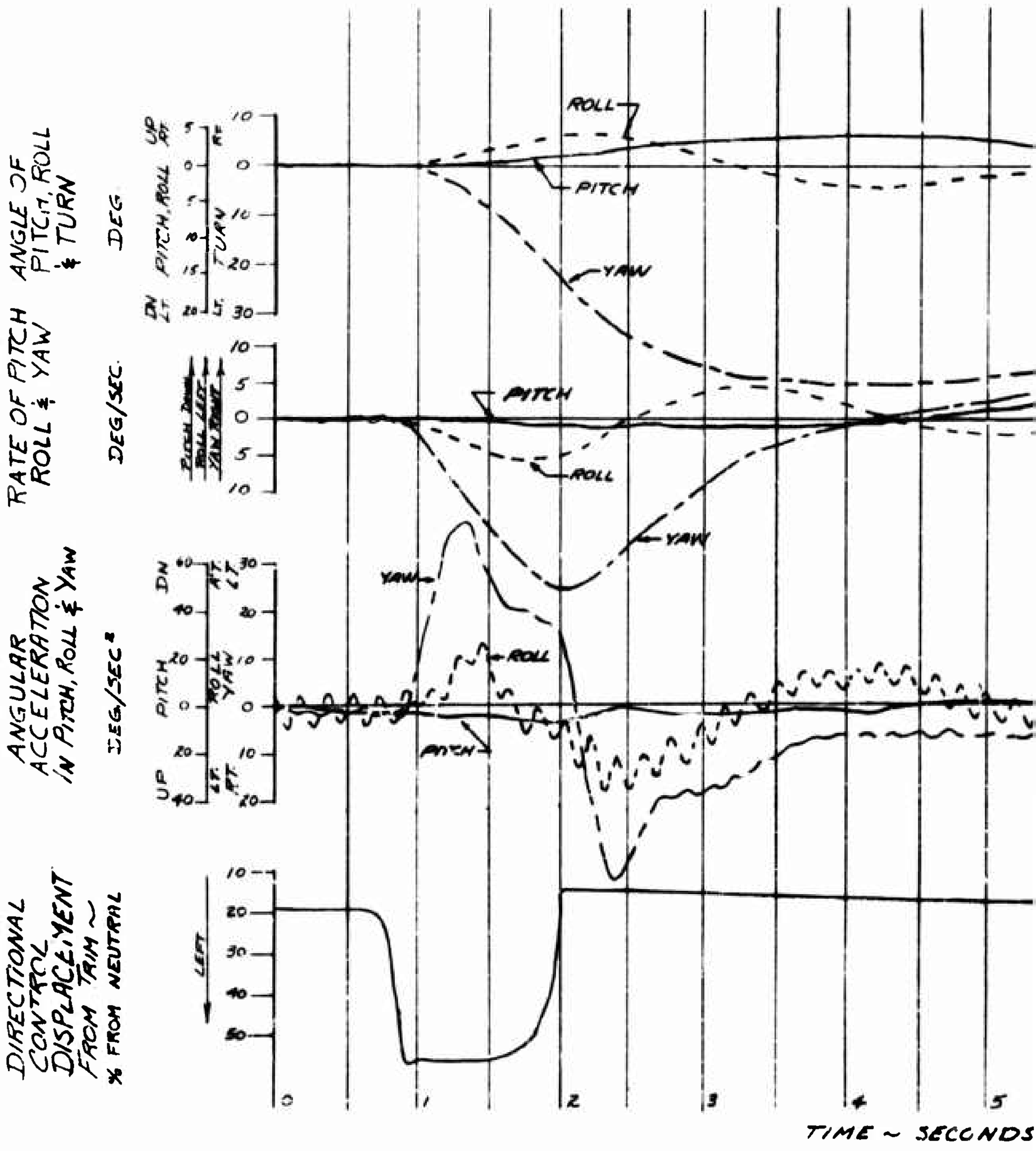


FIGURE NO 21

RESPONSE TO A LEFT DIRECTIONAL PULSE

YHU-1B S/N 58-2078

C.G. LOCATION ~ 1310 (MID) DENSITY ALTITUDE ~ 3000 FT.

ROTOR SPEED ~ 32[illegible] GROSS WEIGHT ~ 6600 LB.

HOVER

PITCH

ROLL & BANK

YAW & TURN

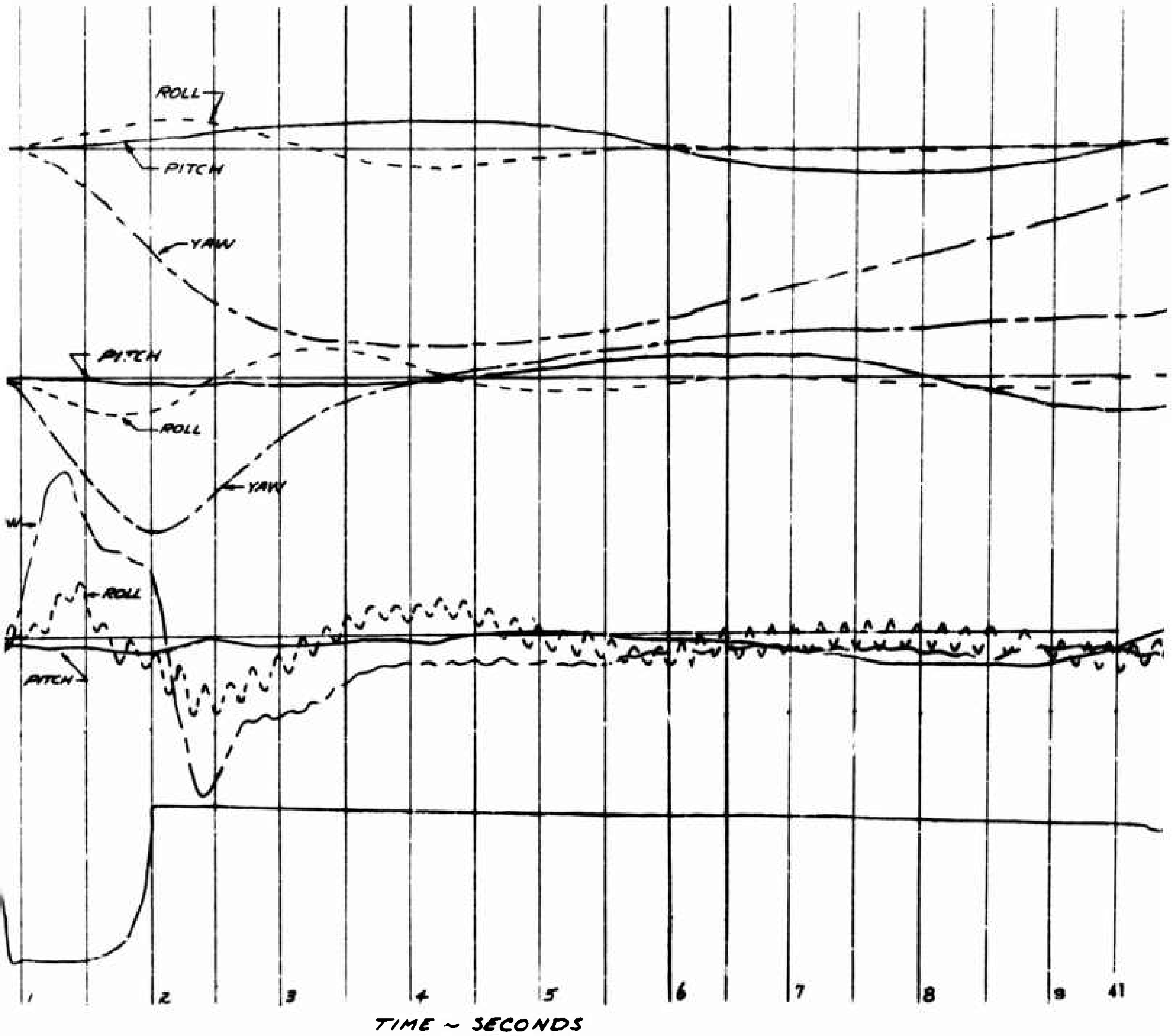


FIG NO 22

LONGITUDINAL CONTROL SENSITIVITY

YHU-1B S/N 58-2078

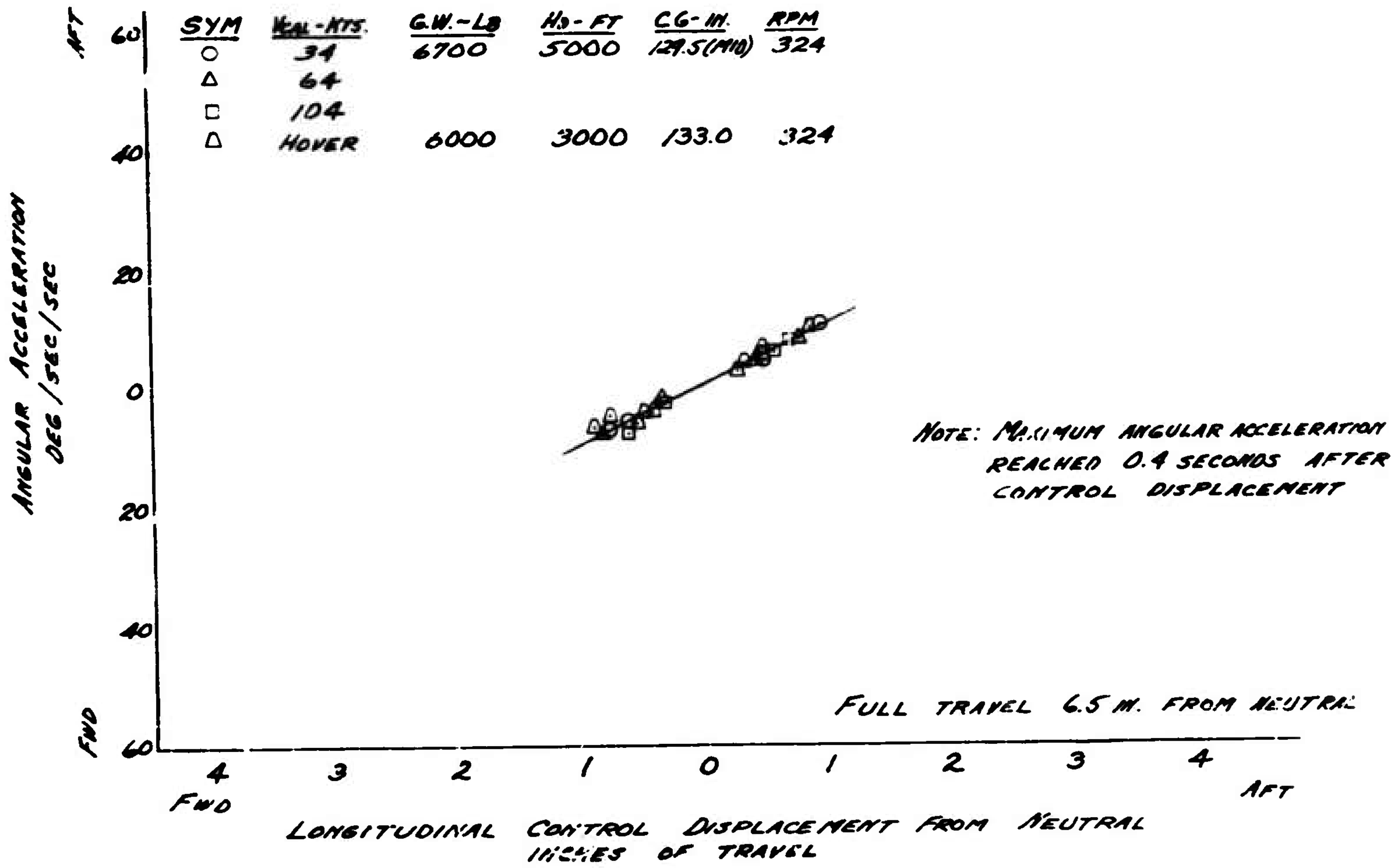


FIG NO 22

LONGITUDINAL CONTROL SENSITIVITY

YHU-1B S/N 58-2078

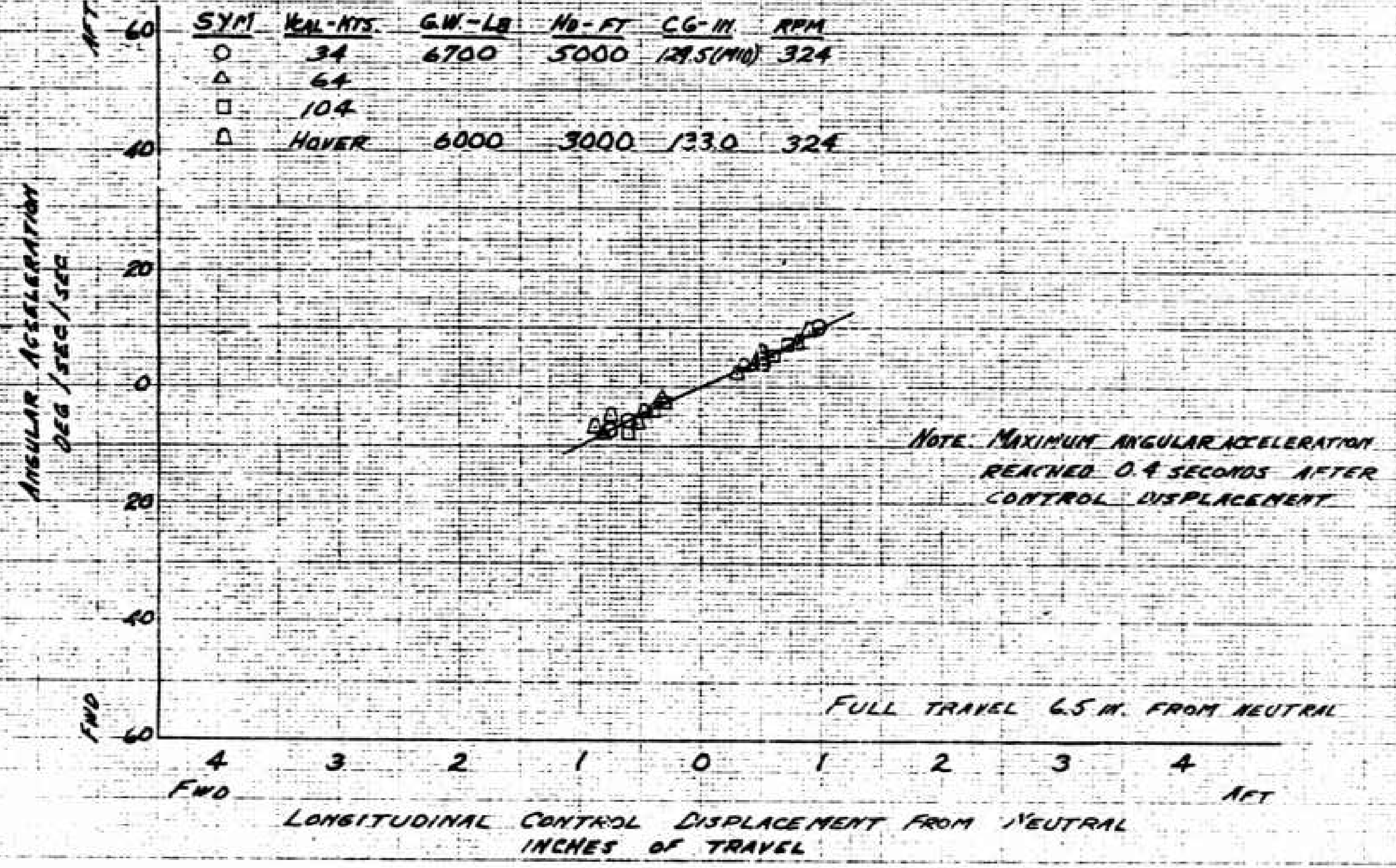


FIG. NO. 23
LATERAL CONTROL SENSITIVITY
YHU-1B S/N 58-2078

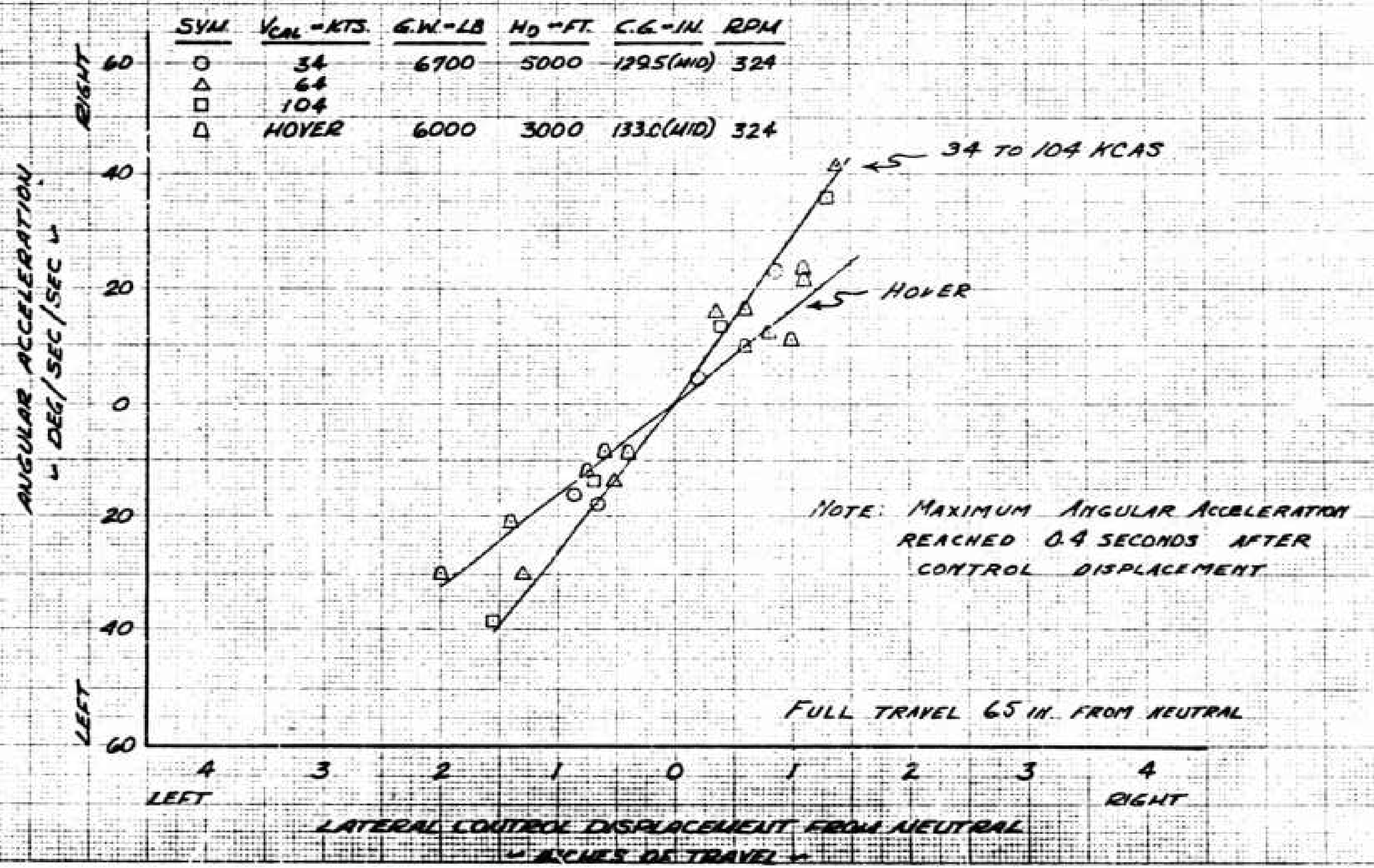


FIG. NO. 24

DIRECTIONAL CONTROL SENSITIVITY

YHU-1? S/N 58-2078

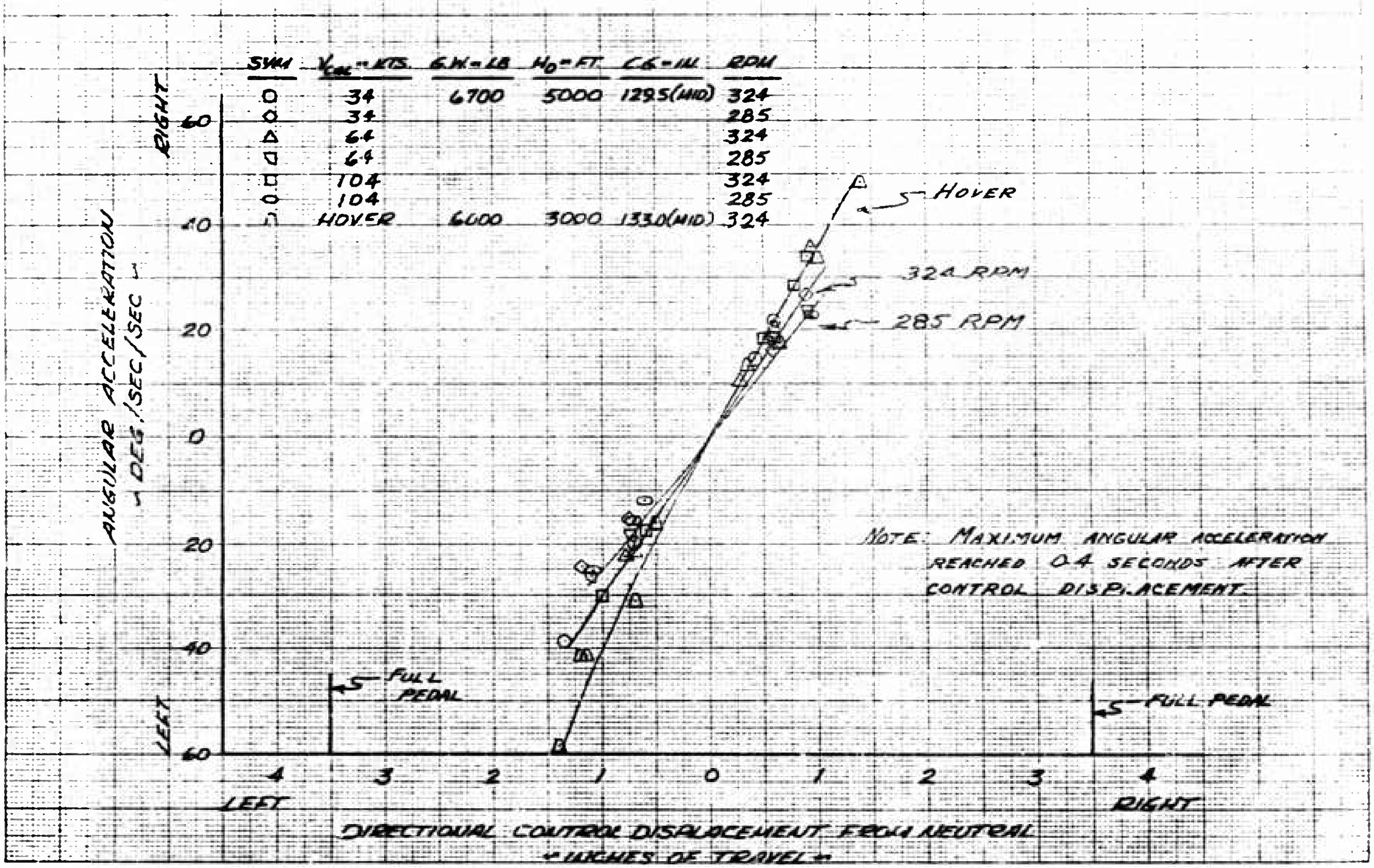


FIG. NO. 25

LONGITUDINAL CONTROL RESPONSE

YHU-1B S/N 58-2078

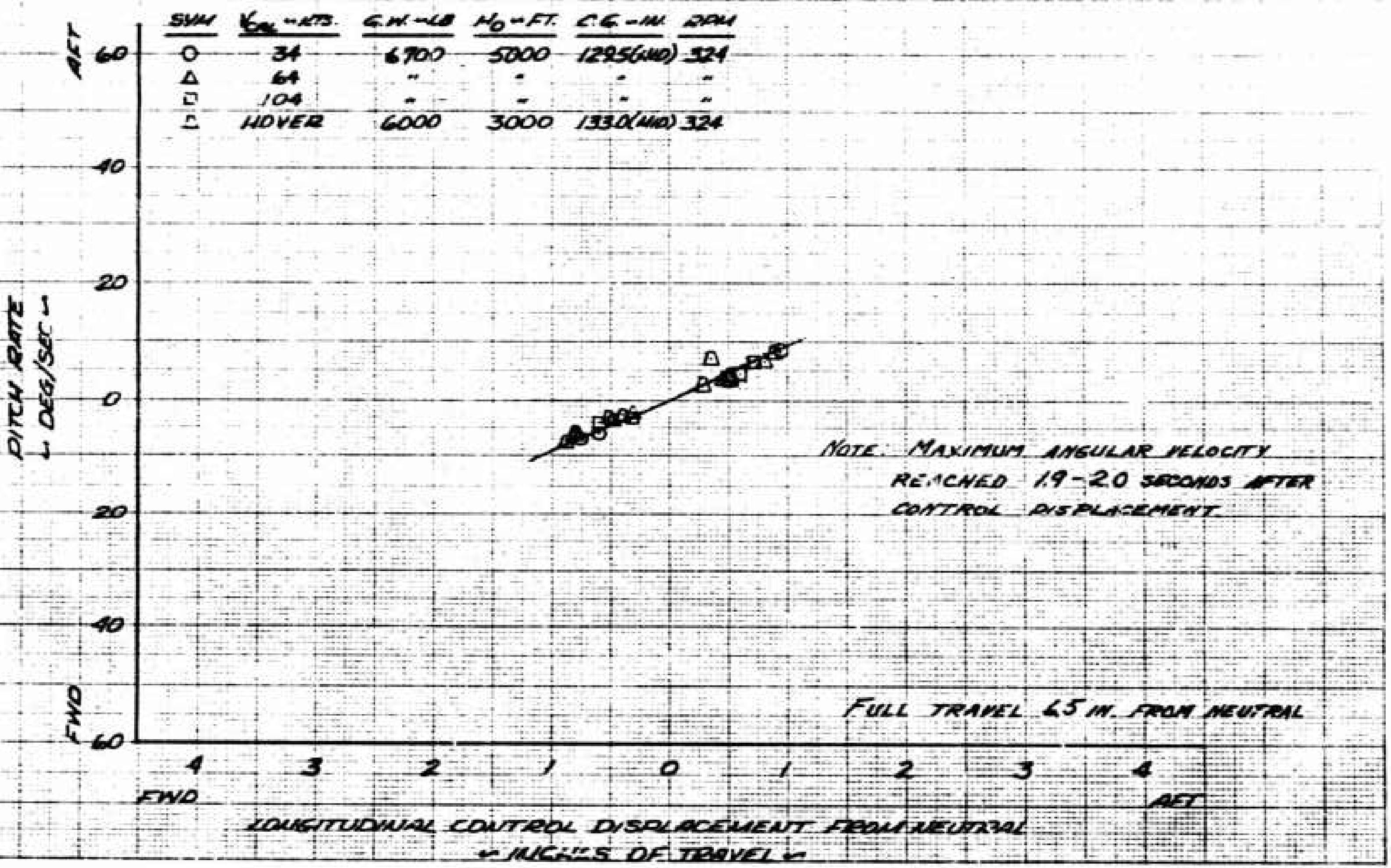


FIG. NO. 26

LATERAL CONTROL RESPONSE

YH-U-1B S/N 58-2078

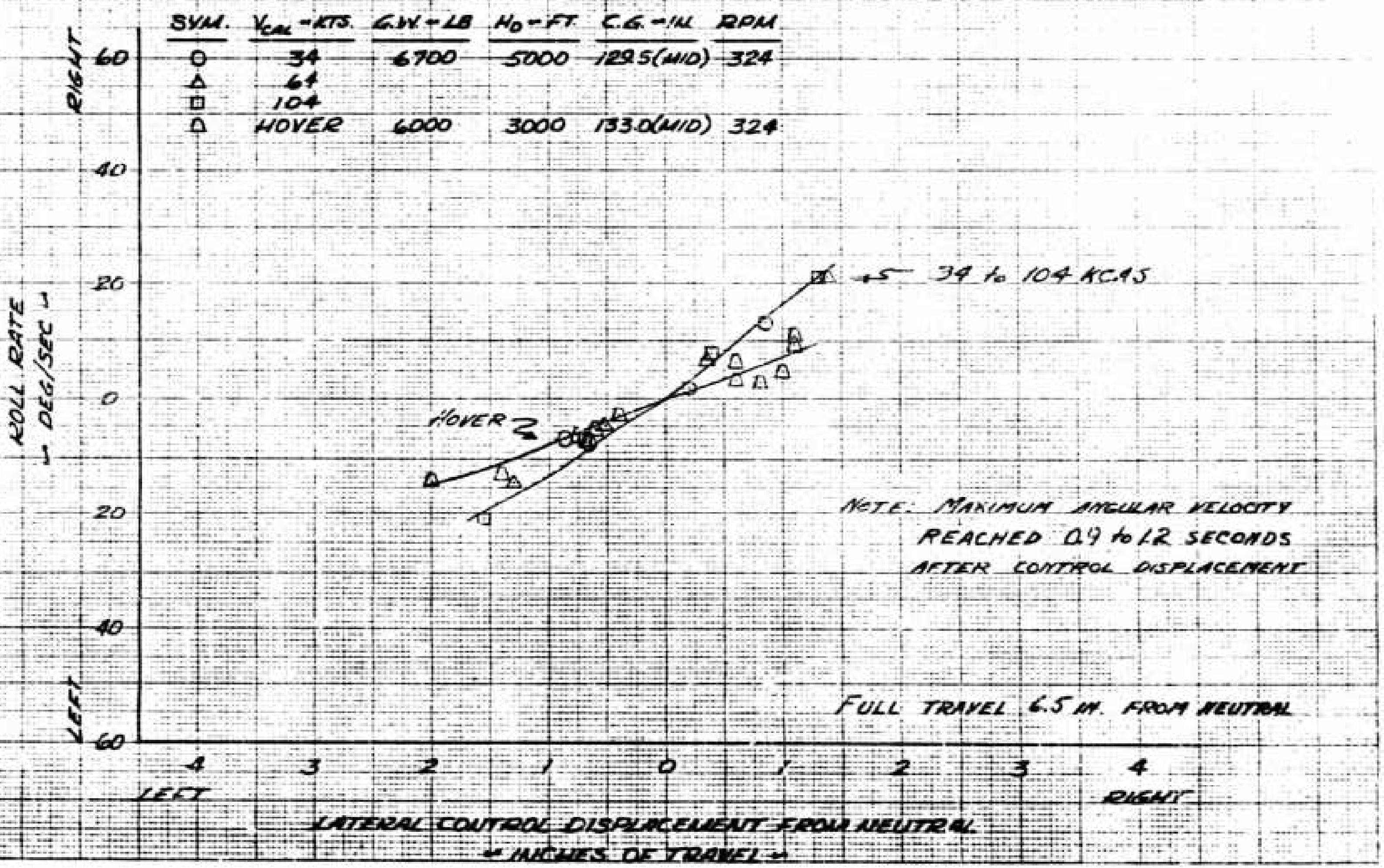
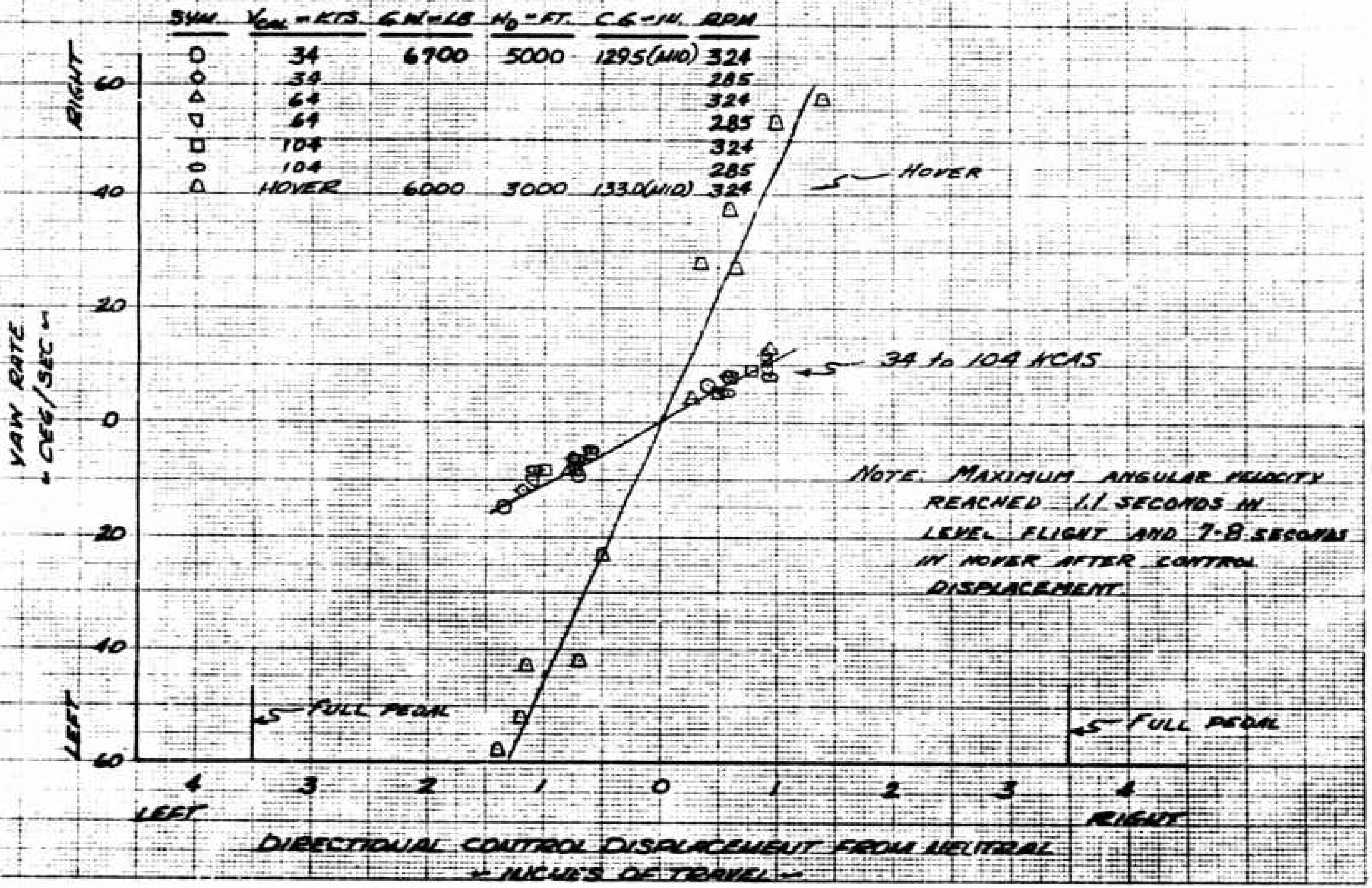


FIG. NO. 27

DIRECTIONAL CONTROL RESPONSE

YHU-1B S/N 58-2078



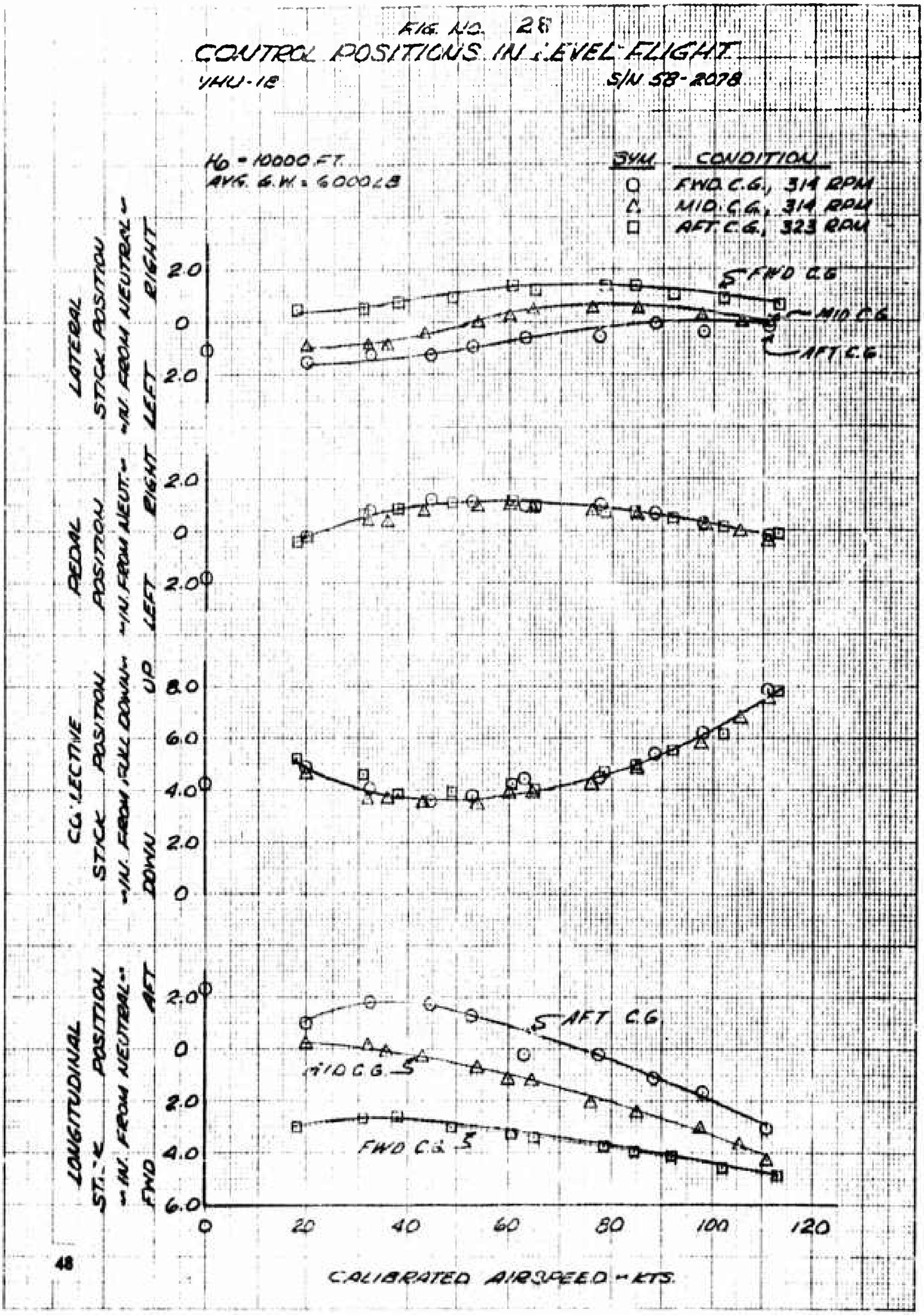


FIG. NO. 28
CONTROL POSITIONS IN LEVEL FLIGHT
YHU-1B
S/N 58-2078
H_0 = 10000 FT.
AVG. G.W. = 6000 LB
SYM. CONDITION
○ FWD C.G., 314 RPM
△ MID C.G., 314 RPM
□ AFT C.G., 323 RPM
FWD C.G.
MID C.G.
AFT C.G.
LATERAL STICK POSITION ~IN. FROM NEUTRAL~ LEFT RIGHT
PEDAL POSITION ~IN. FROM NEUT.~ LEFT RIGHT
COLLECTIVE STICK POSITION ~IN. FROM FULL DOWN~ DOWN UP
LONGITUDINAL STICK POSITION ~IN. FROM NEUTRAL~ FWD AFT
AFT C.G.
MID C.G.
FWD C.G.
CALIBRATED AIRSPEED ~ KTS.

FIG. NO. 29

CONTROL POSITIONS IN LEVEL FLIGHT

YHU-1B S/N58-2078

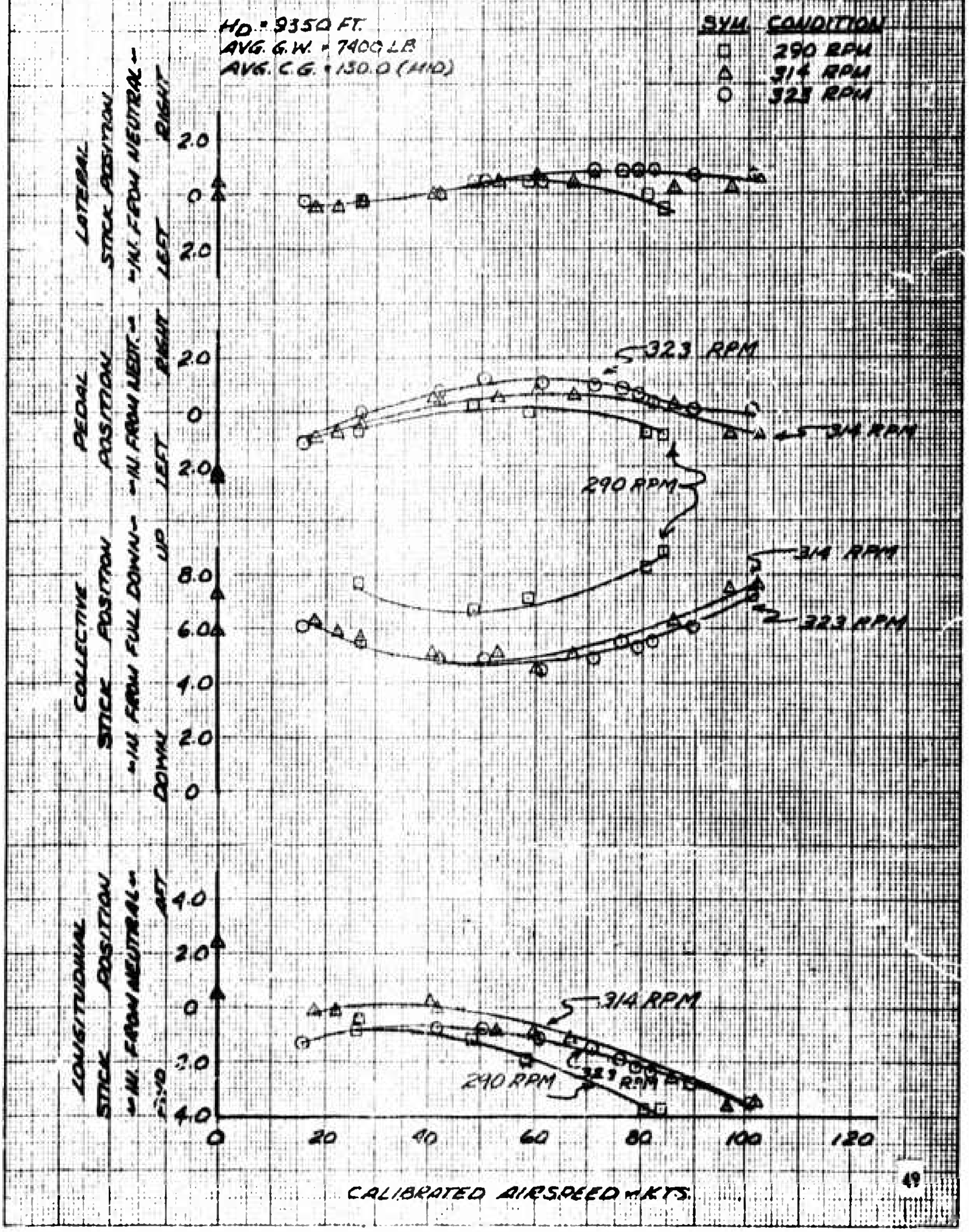
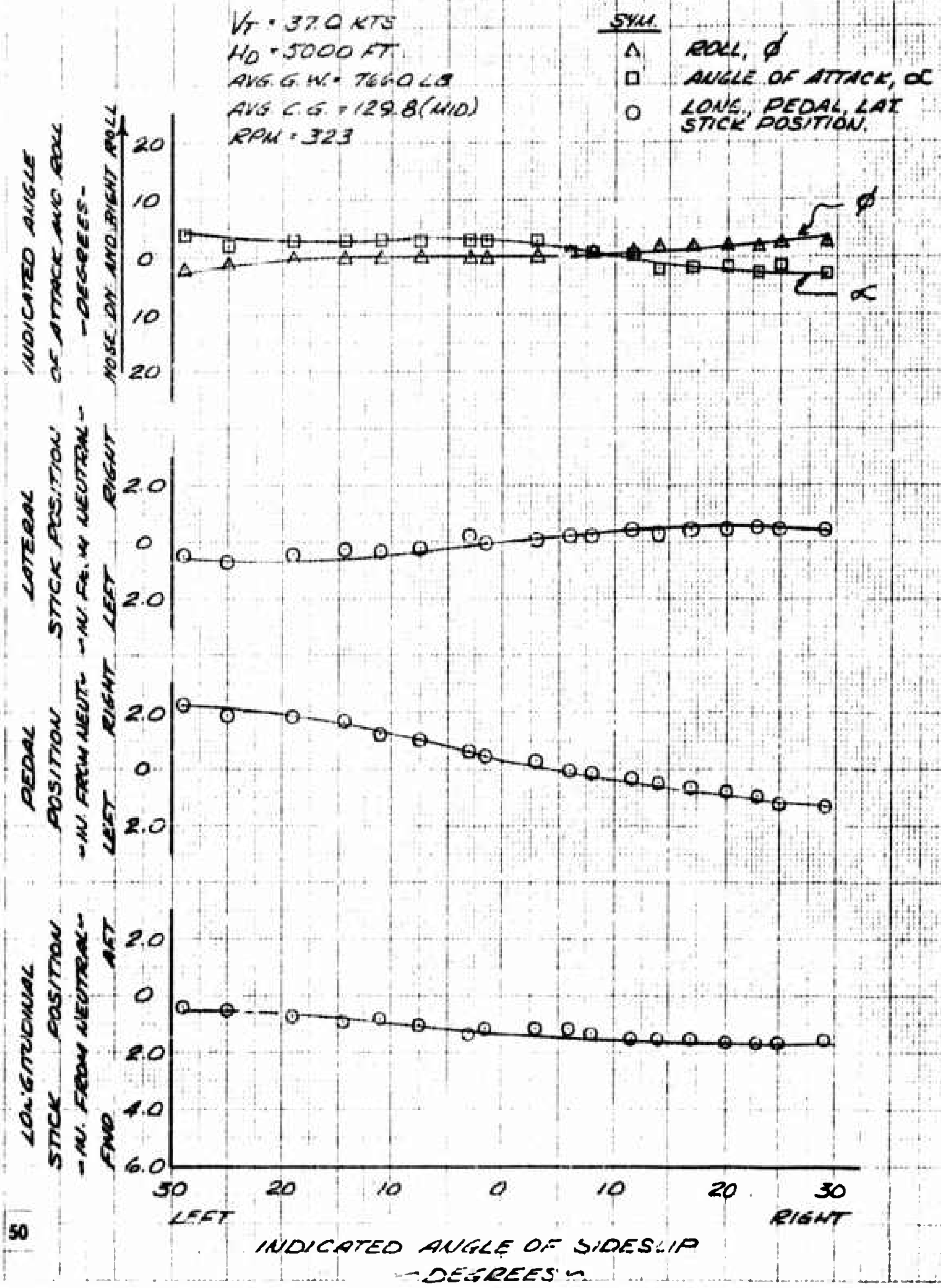


FIG. NO. 30

STATIC DIRECTIONAL STABILITY

YHU-1B S/N 58-2078

LEVEL FLIGHT



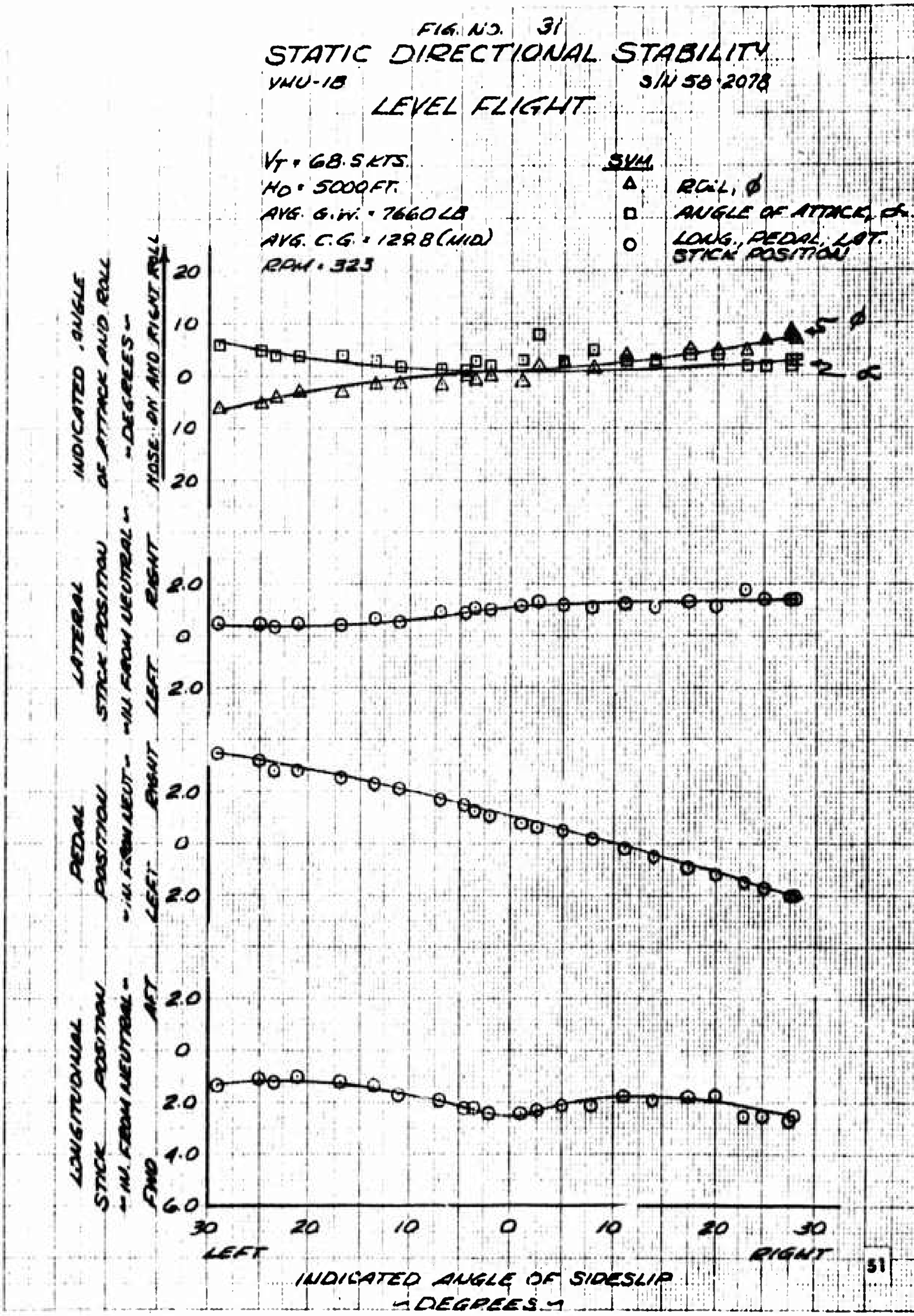


FIG. NO. 31
STATIC DIRECTIONAL STABILITY
YHU-1B
S/N 58-2078
LEVEL FLIGHT
VT = 68.5 KTS.
HD = 5000 FT.
AVG. G.W. = 7660 LB
AVG. C.G. = 129.8 (MID)
RPM = 323
SYM.
ROLL, φ
ANGLE OF ATTACK, α
LONG., PEDAL, LAT. STICK POSITION
INDICATED ANGLE OF ATTACK AND ROLL ~DEGREES~ NOSE: DN AND RIGHT ROLL
LATERAL STICK POSITION ~IN. FROM NEUTRAL~ LEFT RIGHT
PEDAL POSITION ~IN. FROM NEUT.~ LEFT RIGHT
LONGITUDINAL STICK POSITION ~IN. FROM NEUTRAL~ FWD AFT
INDICATED ANGLE OF SIDESLIP ~DEGREES~
LEFT
RIGHT

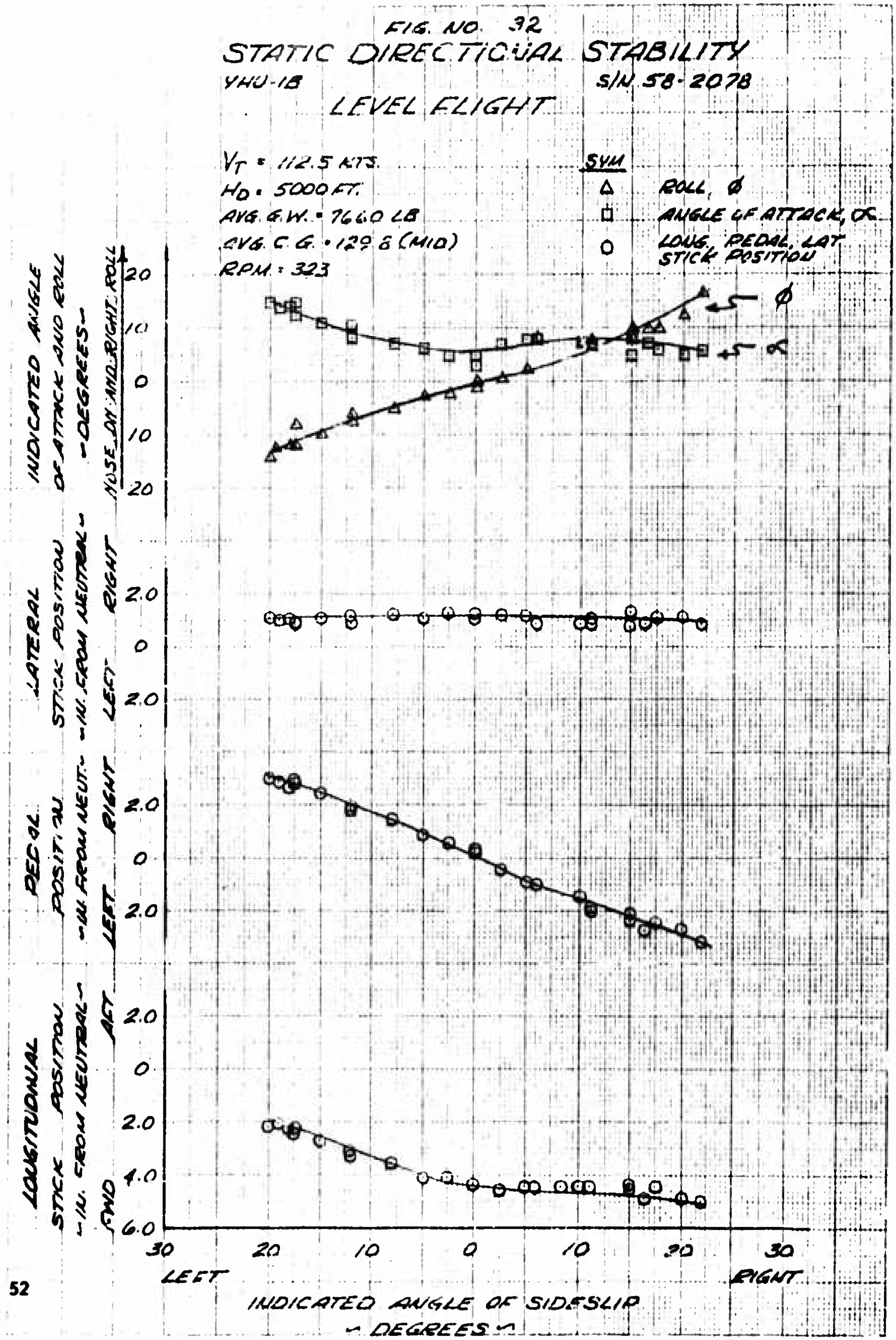


FIG. NO. 32
STATIC DIRECTIONAL STABILITY
YHU-1B
S/N 58-2078
LEVEL FLIGHT
V_T = 112.5 KTS.
H_D = 5000 FT.
AVG. G.W. = 7660 LB
AVG. C.G. = 129.8 (MID)
RPM = 323
SYM
ROLL, φ
ANGLE OF ATTACK, α
LONG, PEDAL, LAT STICK POSITION
INDICATED ANGLE OF ATTACK AND ROLL ~DEGREES~
NOSE DN AND RIGHT ROLL
LATERAL STICK POSITION ~IN. FROM NEUTRAL~
RIGHT
LEFT
PEDAL POSITION ~IN. FROM NEUT.~
RIGHT
LEFT
LONGITUDINAL STICK POSITION ~IN. FROM NEUTRAL~
AFT
FWD
φ
α
LEFT
RIGHT
INDICATED ANGLE OF SIDESLIP ~DEGREES~

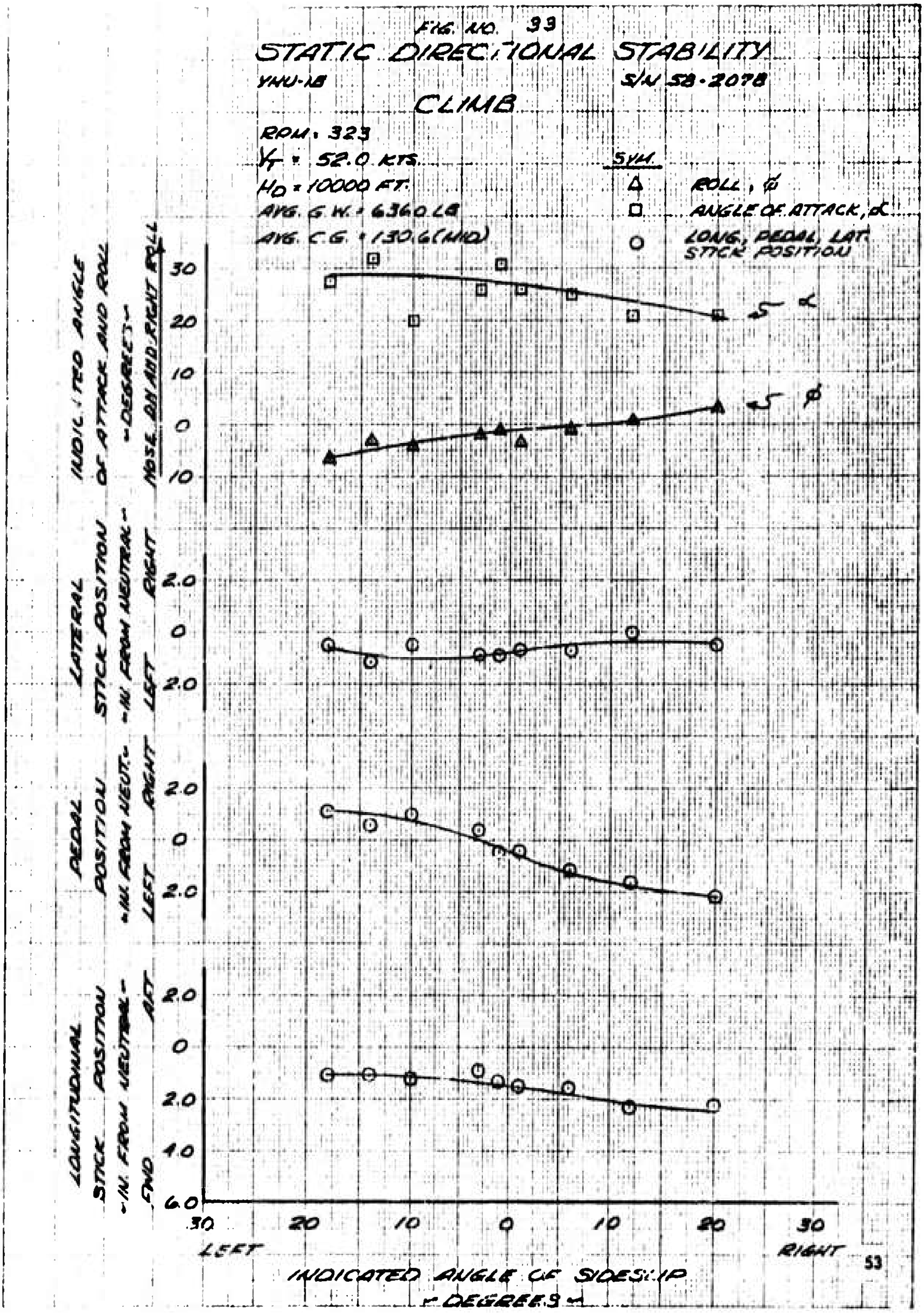


FIG. NO. 33
STATIC DIRECTIONAL STABILITY
YHU-1B
S/N 58-2078
CLIMB
RPM = 323
V_T = 52.0 KTS.
H_D = 10000 FT.
AVG. G.W. = 6360 LB
AVG. C.G. = 130.6(MID)
SYM.
ROLL, φ
ANGLE OF ATTACK, α
LONG., PEDAL, LAT. STICK POSITION
INDICATED ANGLE OF ATTACK AND ROLL ~DEGREES~ NOSE DN AND RIGHT ROLL
LATERAL STICK POSITION ~IN. FROM NEUTRAL~ LEFT RIGHT
PEDAL POSITION ~IN. FROM NEUT.~ LEFT RIGHT
LONGITUDINAL STICK POSITION ~IN. FROM NEUTRAL~ FWD AFT
30
20
10
0
10
2.0
0
2.0
2.0
0
2.0
2.0
0
2.0
4.0
6.0
30
20
10
0
10
20
30
LEFT
RIGHT
INDICATED ANGLE OF SIDESLIP ~DEGREES~

FIG. NO. 34

STATIC DIRECTIONAL STABILITY

YHU-1B S/N 58-2078

AUTOROTATION

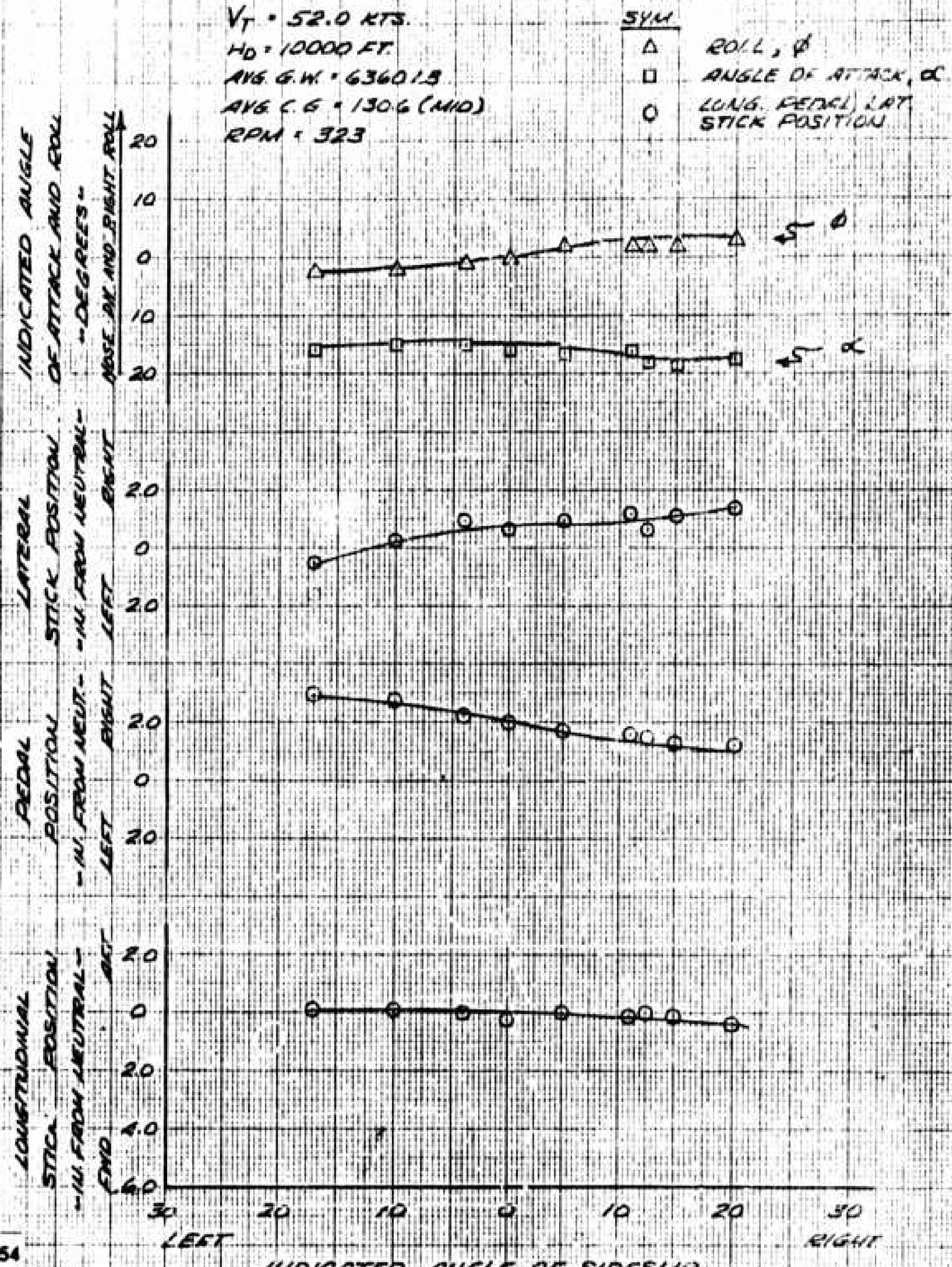


FIG. NO. 35

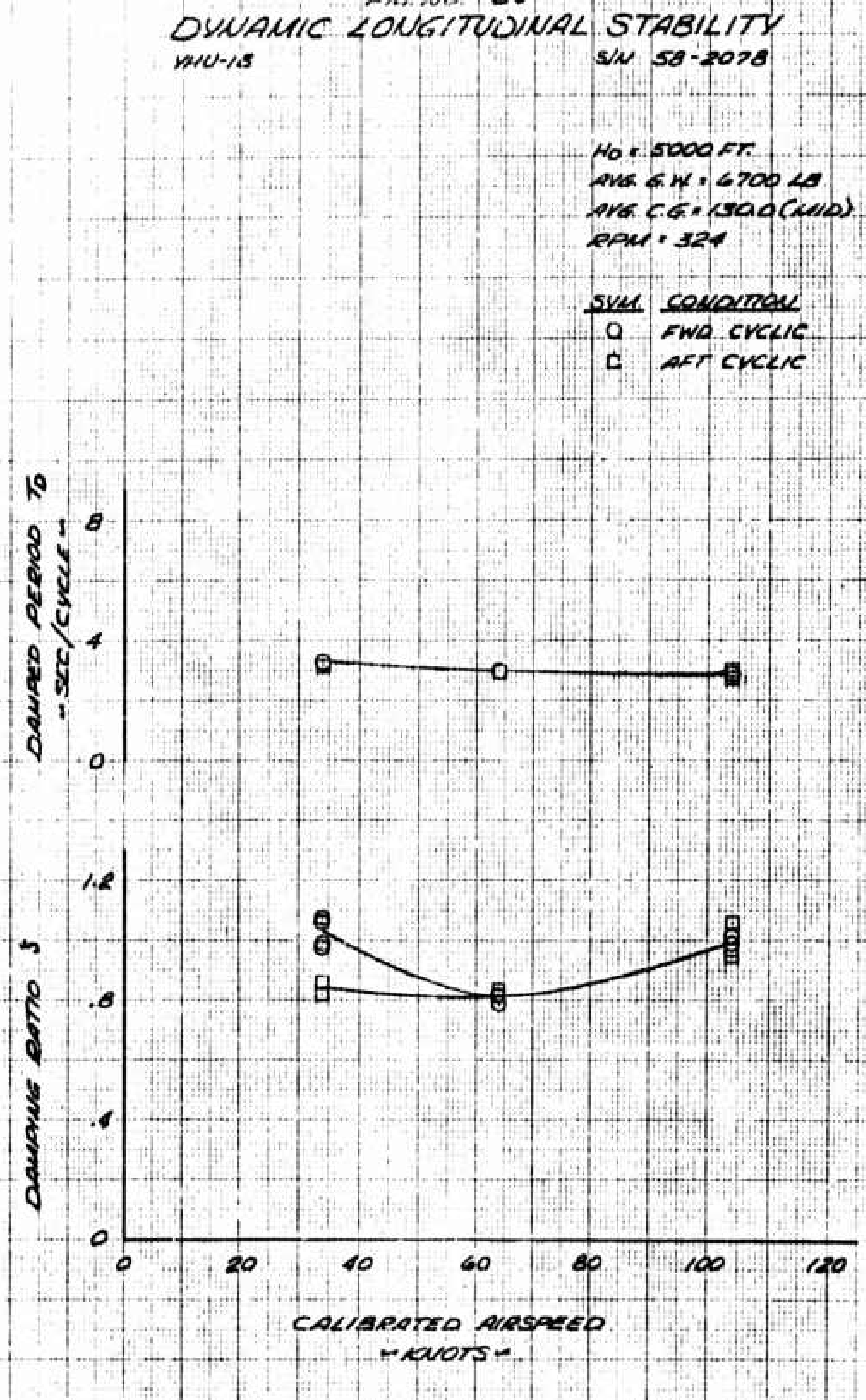

DYNAMIC LONGITUDINAL STABILITY
YHU-1B
S/N 58-2078
Ho = 5000 FT.
AVG. G.W. = 6700 LB
AVG. C.G. = 130.0 (MID)
RPM = 324
SYM. CONDITION
FWD CYCLIC
AFT CYCLIC
DAMPED PERIOD TD ~SEC/CYCLE~
DAMPING RATIO ζ
CALIBRATED AIRSPEED ~KNOTS~
0
4
8
.4
.8
1.2
20
40
60
80
100
120

FIG. NO. 36

DYNAMIC DIRECTIONAL STABILITY

YHU-1B S/N 58-2078

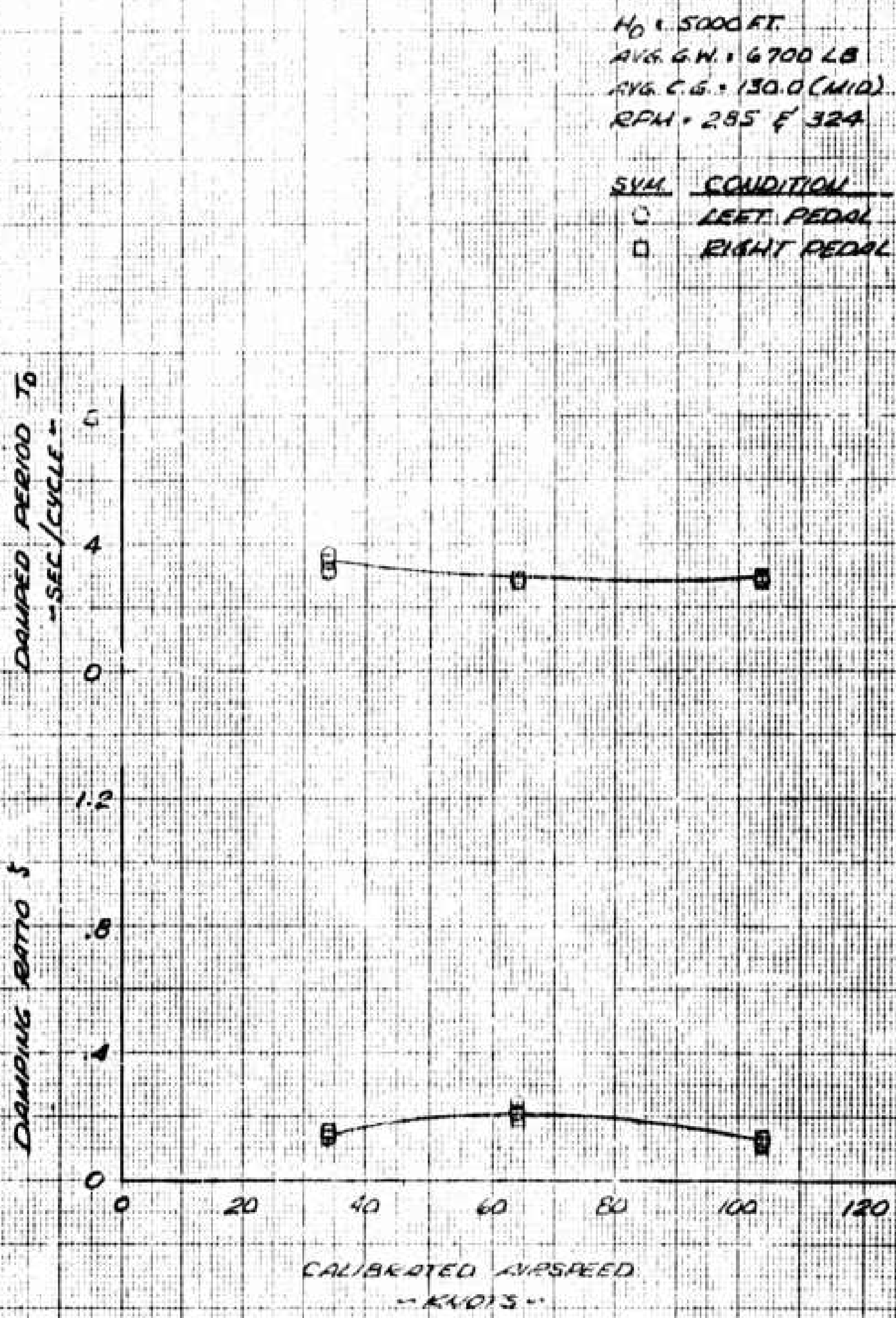


FIG. NO. 37

CONTROL POSITIONS IN SIDEWARD FLIGHT

YHU-1B

S/N 58-2078

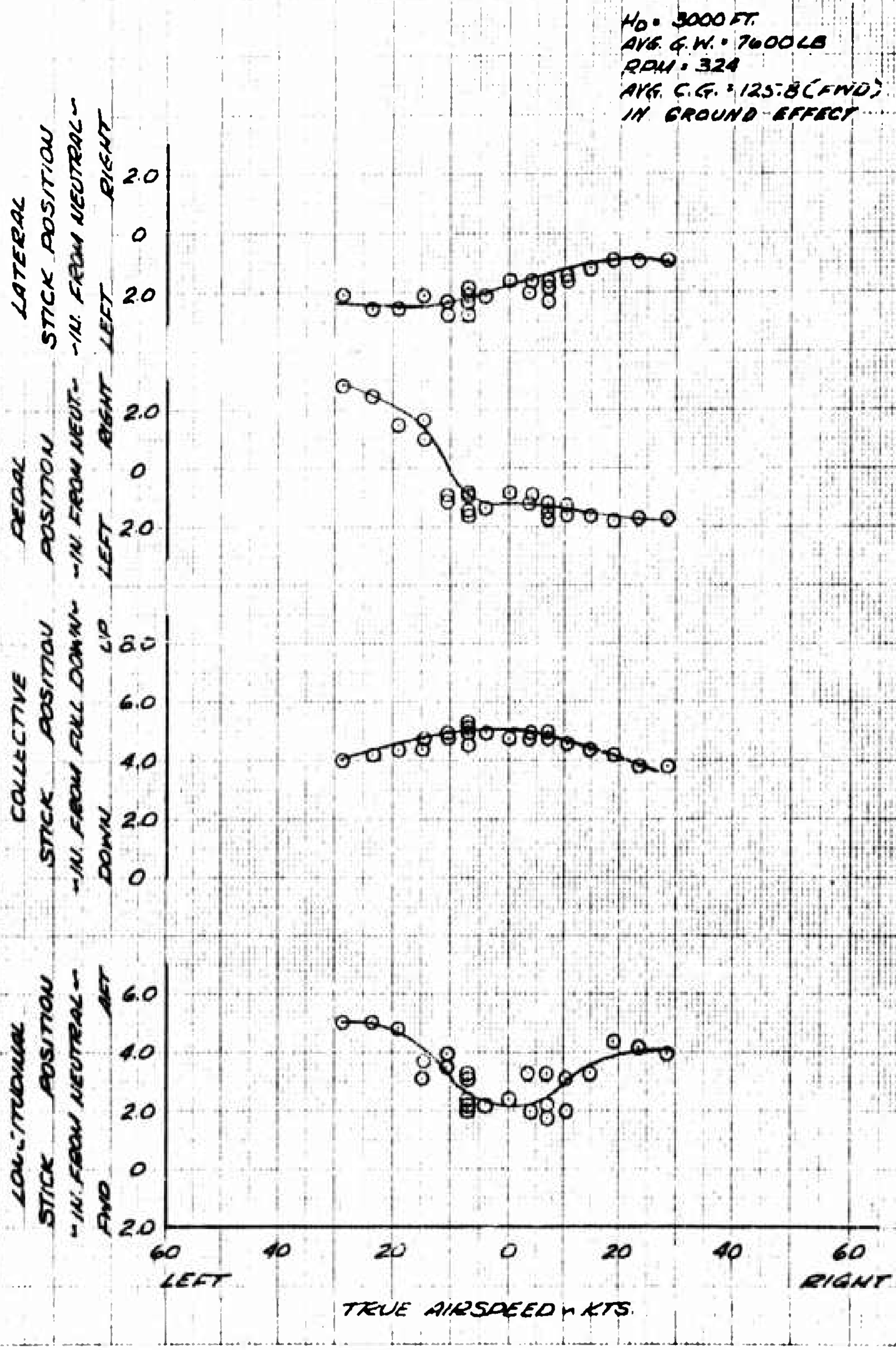


FIG. NO. 38

CONTROL POSITIONS IN FORWARD AND REARWARD FLIGHT

YHU-1B

S/N 58-2078.

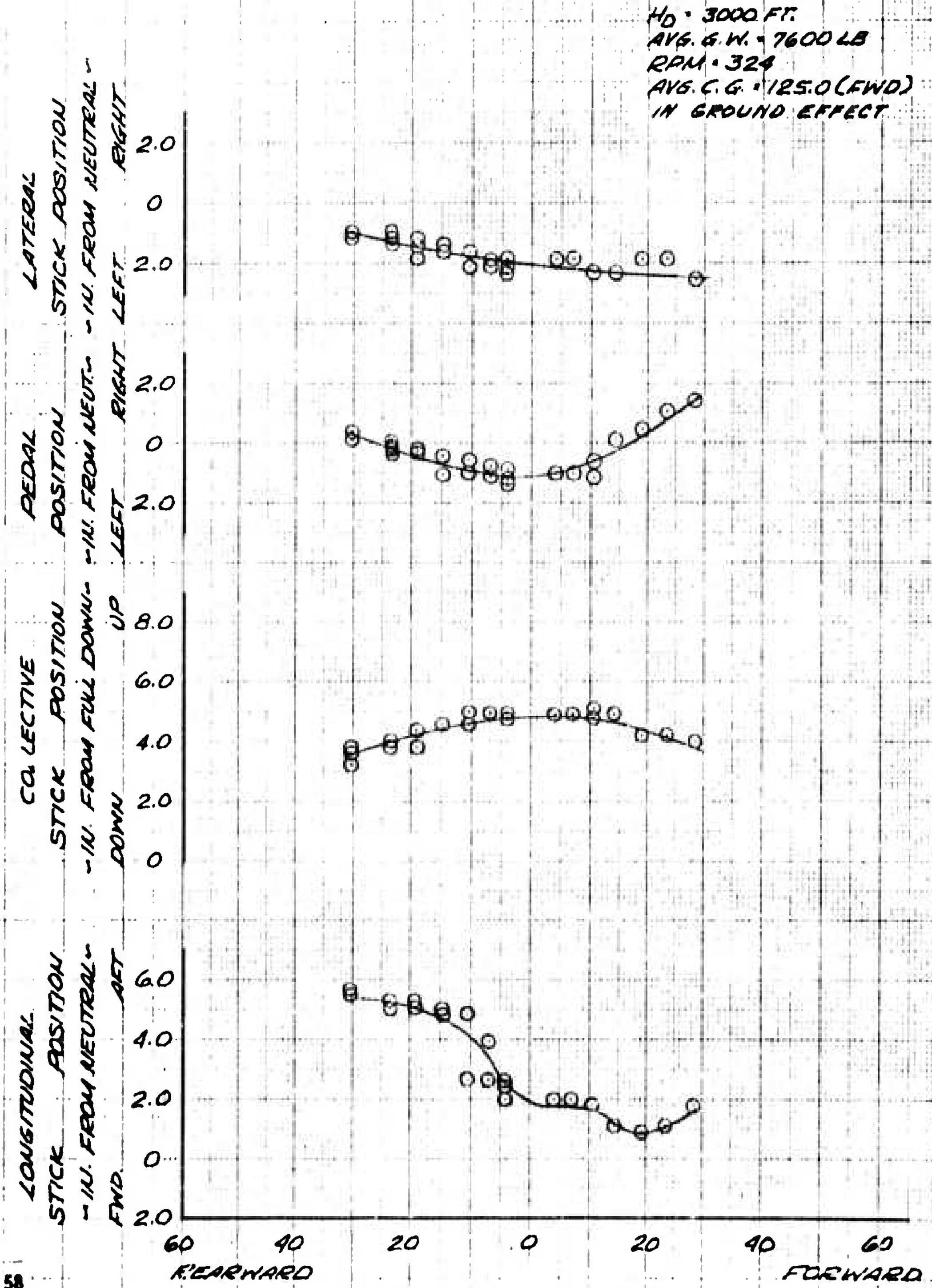
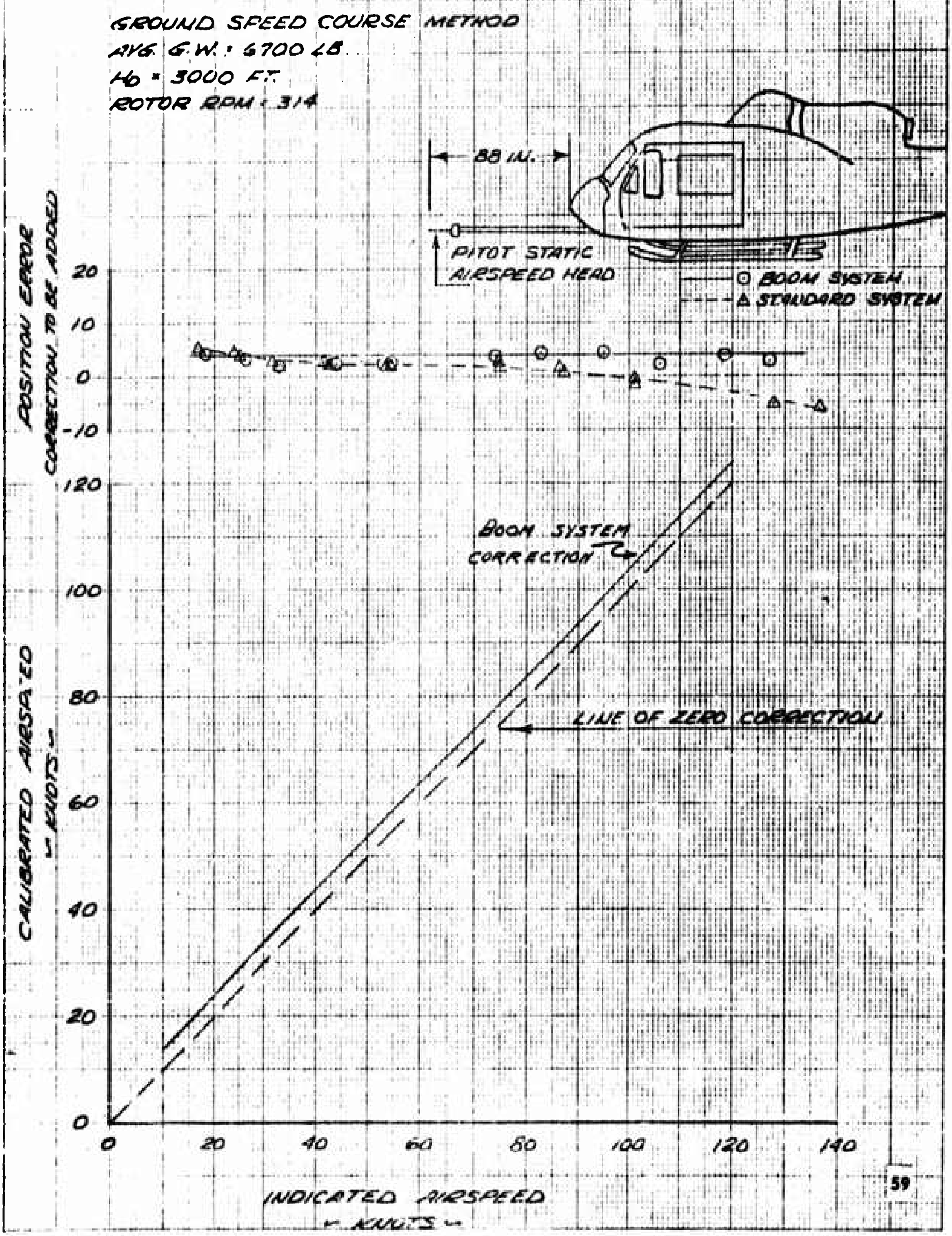
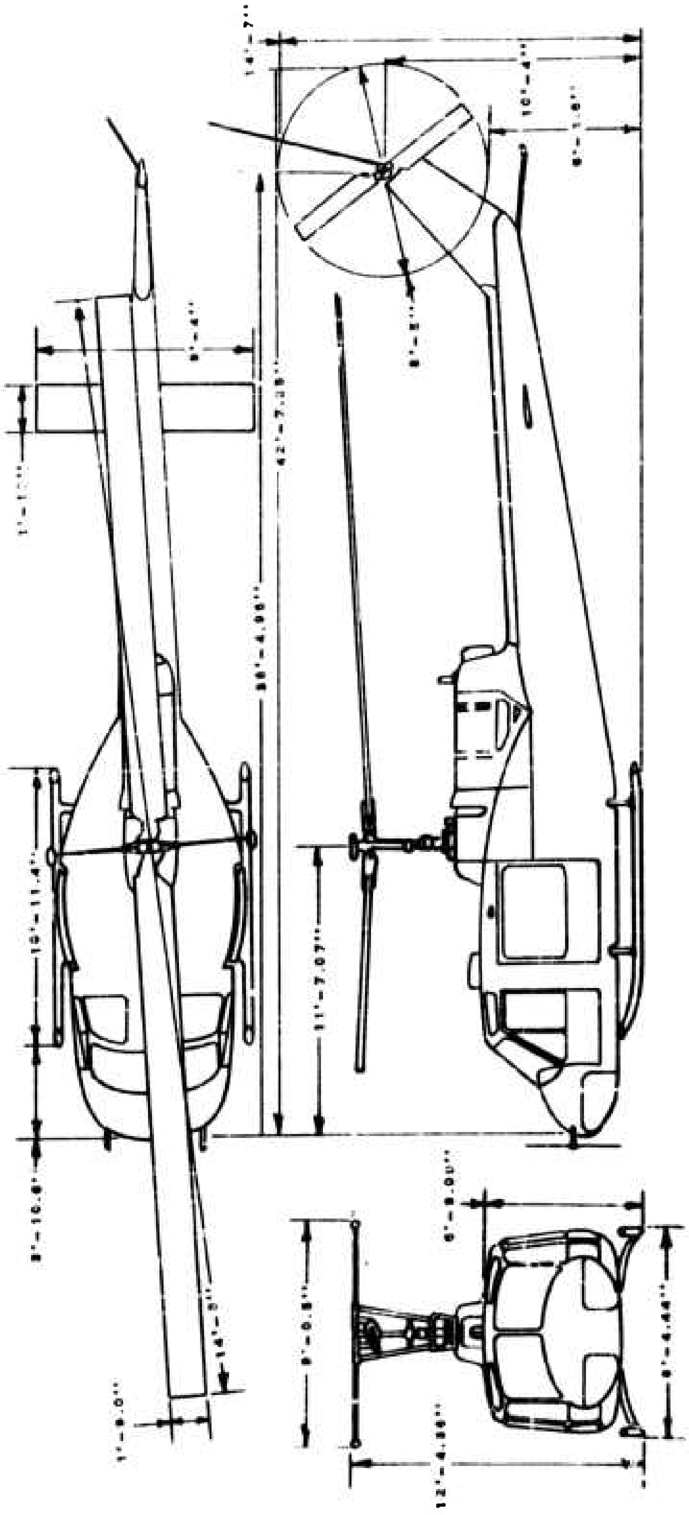


FIG. NO. 39
AIRSPEED CALIBRATION
YHU-1B S/N 58-2078





APPENDIX II

general aircraft information

DIMENSIONS AND DESIGN DATA

Overall Dimensions:

Aircraft length (nose to tail skid)	39.5 ft
Aircraft length (rotors turning)	54 ft
Width of skids	8.4 ft
Height (to top of turning tail rotor)	14.7 ft
Height (to top of rotor mast)	12.5 ft

Main Rotor:

Number of blades	2
Rotor diameter	44 ft
Rotor solidity	0.0509
Swept area	1520.5 ft^2
Blade area (each)	38.3 ft^2
Blade chord (root to tip)	21 in
Blade airfoil (root to tip)	NACA 0012
Flapping angle	$\pm$12 deg
Collective pitch angle limits (at 75 percent radius)	0 to +12 deg
Preconing angle	4 deg

Tail Rotor:

Number of blades	2
Rotor diameter	8.5 ft
Rotor solidity	0.105
Swept area	56.8 ft^2
Blade area (each)	2.98 ft^2
Blade chord (root to tip)	0.7 ft
Blade airfoil (root to tip)	NACA 0015
Blade twist	0 deg
Flapping angle	$\pm$8 deg

Gear Ratios:

Power turbine to engine output shaft	3.22 to 1
Engine output shaft to rotor	20.37 to 1
Engine output shaft to tail rotor	3.97 to 1

Flight Limits:

Forward	Sta. 125.0
Aft	Sta. 138.0
Rotor hub centerline	Sta. 131.9[illegible]
Design minimum rotor speed (power on and power off)	285 rpm
Design maximum rotor speed for continuous operation (power on)	323 rpm
Maximum governed rotor speed for test aircraft	323 rpm
Maximum rotor speed for autorotation	330 rpm*
Structural limit rotor speed (power on and power off)	356 rpm
Limit dive speed	168 KTAS
Design maximum sideward speed	30 KTAS
Design maximum rearward speed	30 KTAS

*Changed to 339 rpm, Revision A to Design Specification.

Control Travel:

Cyclic, full forward to full aft	13 in
full left to full right	13 in
Pedal, full left to full right	7 in
Collective, full down to up	12.2 in

POWER PLANT

The test aircraft was equipped with a Lycoming T53-L-5 gas turbine engine S/N LE 03007. This engine is designed to produce 960 shaft horsepower for takeoff at 6600 rpm (engine output shaft speed) with sea level standard day conditions.

For this test the fuel control was trimmed so the engine could produce 1100 shaft horsepower.

A torquemeter is installed integral with the reduction gearing of this engine. Torque is found by measuring the difference between the torquemeter hydraulic pressure and the inlet housing pressure. Lycoming calibrated the engine-torquemeter combination prior to delivery of the engine. The results of this calibration are presented as Figs. 1, 2 and 3 of this Appendix. The torquemeter calibration (Fig. 1) was used to determine power during the test program.

SYSTEMS

General:

The rotor and control systems and the engine fuel control are essentially the same as those of the earlier HU-1 series which is adequately described in AFFTC-TR-59-33.

Transmission:

The transmission consists of a single stage bevel gear and a two stage planetary gear train. This unit is connected to the engine output shaft, through a free wheeling unit, by a short drive shaft. Engine output shaft rpm is reduced to main rotor speed at a ratio of 20.37 to 1.

This transmission is designed to transmit 1100 shaft horsepower at 6600 rpm power turbine speed. Near the end of the program the transmission was limited because of a failure during the transmission qualification runs. At the time of this writing the following restrictions are in force:

990 SHP at 6600 rpm

120 knots maximum indicated airspeed

WEIGHT AND BALANCE

The test aircraft was delivered partially instrumented. Therefore the aircraft was weighed fully instrumented. In this condition the aircraft was found to have a basic weight of 4870 pounds. The center of gravity was at station 138.7.

Tests were flown at weights ranging from 5800 pounds to the maximum internal load of 7660 pounds. Most tests were flown at a station 131.5 (mid) center of gravity, however two tests were flown at station 125.0 (forward) and one flight was made with the center of gravity located at station 138 (aft).

TEST INSTRUMENTATION

The instrumentation used during the tests was supplied, calibrated and maintained by the Instrumentation Branch of the Air Force Flight Test Center. The following sensitive instrumentation was installed:

Cockpit Instrument Panel:

Rotor rpm
Gas producer rpm
Exhaust gas temperature
High torque pressure
Low torque pressure
Outside air temperature
Total fuel used
Airspeed (ship's system)
Airspeed (boom)
Altitude (boom)
Angle of sideslip (boom)
Rate of climb
Stepper Motor

Photo-Recorder:

Outside air temperature
Compressor inlet temperature
Total fuel used
Airspeed (boom)
Altitude (boom)
High torque pressure
Low torque pressure
Combustor static pressure
Compressor discharge total pressure
Tailpipe static pressure
Rotor rpm

Gas producer rpm
Compressor inlet pressure static
Bellmouth inlet total pressure
Compressor discharge total
  temperature
Exhaust gas temperature
Clock
Event marker

The following parameters were recorded on the oscillograph:

Airspeed (boom)
Altitude (boom)
High torque pressure
Pedal position
Longitudinal stick position
Lateral stick position
Collective stick position
Angle of bank
Angle of pitch
Angle of turn
Rate of pitch
Rate of roll
Rate of yaw
Angular acceleration in pitch
Angular acceleration in roll
Angular acceleration in yaw
Total fuel used
Rotor rpm

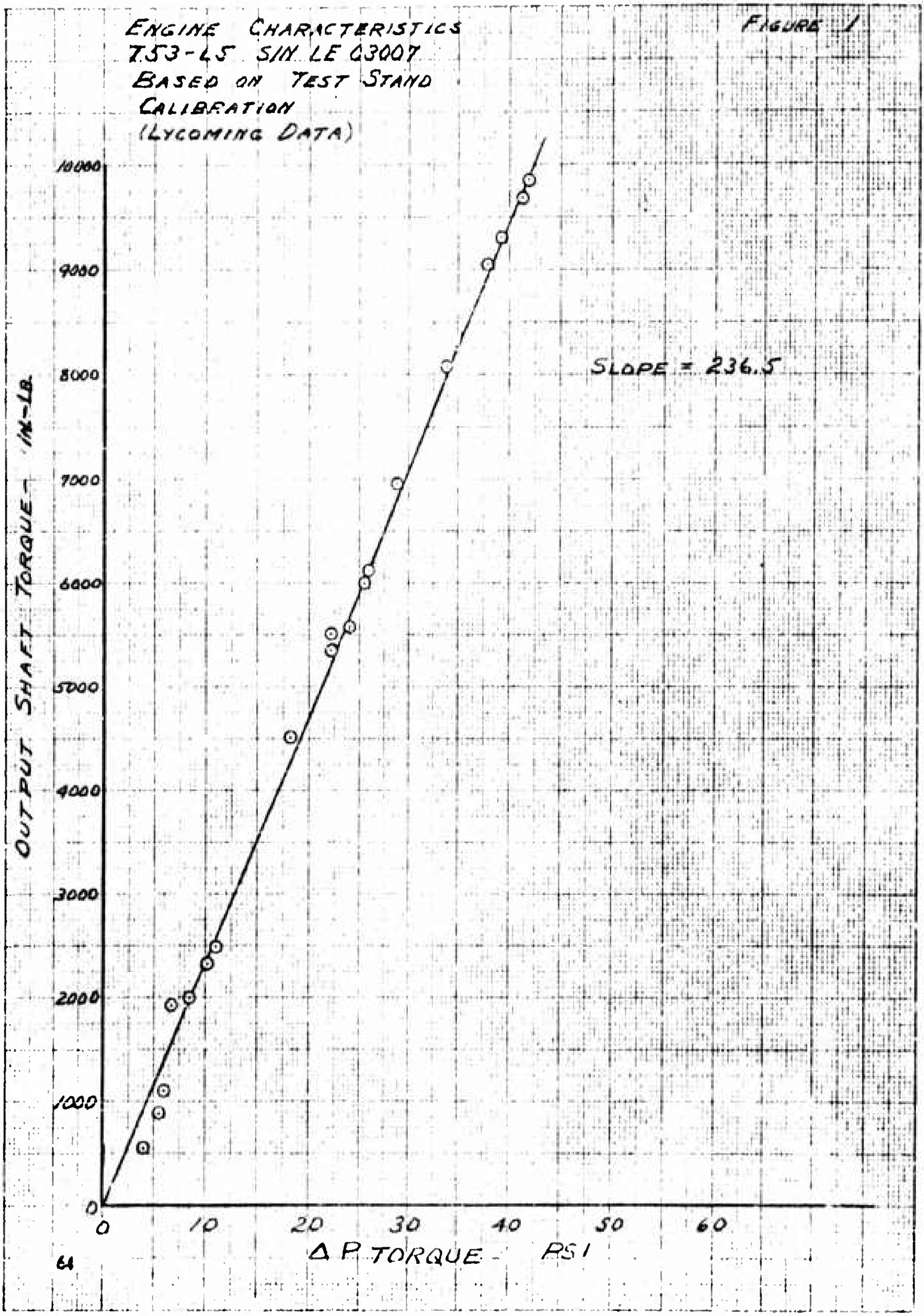
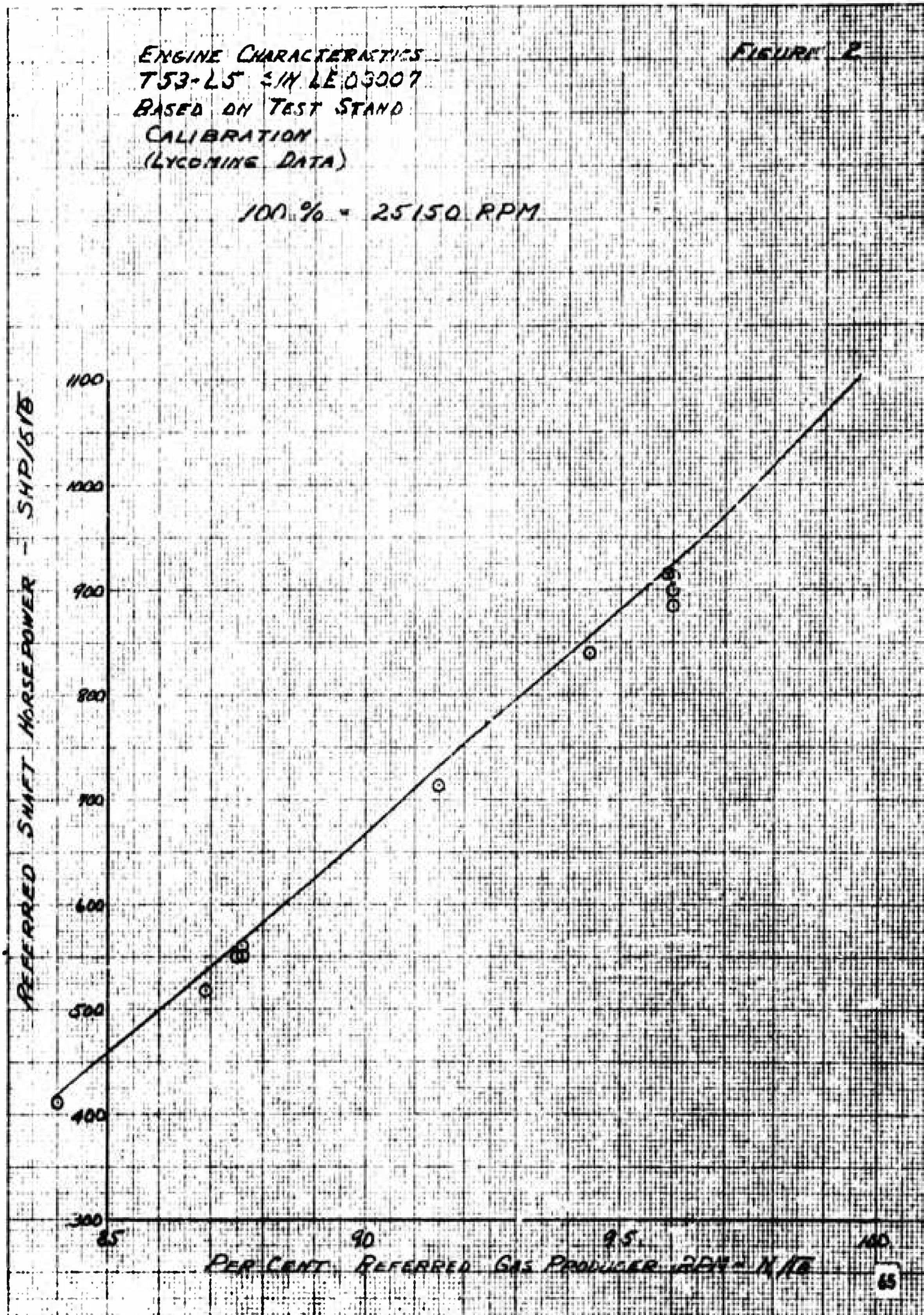
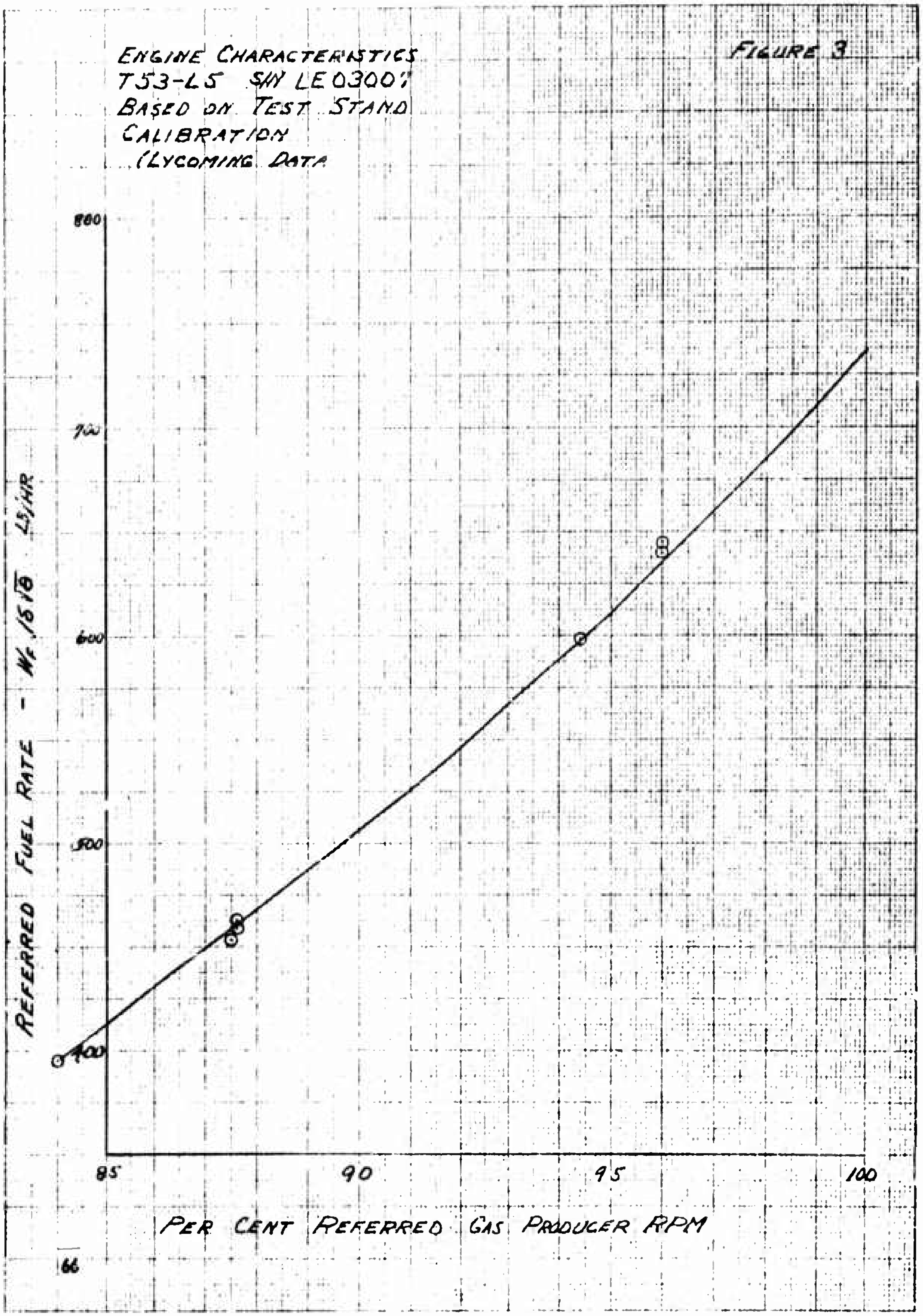


FIGURE 1
ENGINE CHARACTERISTICS
T53-L5 S/N LE 03007
BASED ON TEST STAND
CALIBRATION
(LYCOMING DATA)
SLOPE = 236.5
OUTPUT SHAFT TORQUE - IN-LB.
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
ΔP TORQUE - PSI



ENGINE CHARACTERISTICS
T53-L5 S/N LE 03007
BASED ON TEST STAND
CALIBRATION
(LYCOMING DATA)
FIGURE 2
100% = 25150 RPM
REFERRED SHAFT HORSEPOWER - SHP/δ√θ
1100
1000
900
800
700
600
500
400
300
85
90
95
100
PER CENT REFERRED GAS PRODUCER RPM - N/√θ



ENGINE CHARACTERISTICS
T53-L5 S/N LE0300?
BASED ON TEST STAND
CALIBRATION
(LYCOMING DATA
FIGURE 3
REFERRED FUEL RATE - $W_f/\delta\sqrt{\theta}$ LB/HR
800
700
600
500
400
85
90
95
100
PER CENT REFERRED GAS PRODUCER RPM

APPENDIX III

test
data
corrected
for
instrument
error

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 56-2076

Pilot CAPT BALFE

Test AIRSPEED CALIBRATION Flight No. 4 Date 5 Oct 60

ESGW 6700 lb. FSW 6.34 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	2210	2140	2220	2140	2180	2160	2240	2210
Skid Height ft.								
Gross Weight lb.	6608	6594	6562	6542	6522	6507	6484	6468
Thrust lb.								
IAS (Boom) kt.	113.0	113.0	101.0	101.0	90.8	90.5	81.0	81.0
Time min:sec.	0:16.7	0:18.0	0:18.6	0:11.9	20.9	12.7	25.1	23.5
Fuel Used gal.	14.5	16.7	21.8	24.9	28.1	30.5	34.0	36.5
N_1 percent								
N_R Rotor rpm								
High Torque Press. in. Hg								
Low Torque Press. in. Hg								
OAT °C	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75
$T_{t_{am}}$ °C								
T_{t_1} °C								
P_{t_1} in. H_2O								
P_{s_1} in. H_2O								
P_{s_4} in. Hg								
P_{t_3} in. Hg								
T_{t_3} °C								
Altitude (Ref) ft.								
Course Length - Ft	3580	3580	3580	2695	3580	2690	3580	3580

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 56-2076

Pilot CAPT BALFE

Test AIRSPEED CALIBRATION   Flight No. 4   Date 5 Oct 60

ESGW 6700 lb.   FSW 6.34 lb/gal.

Point No.	9	10	11	12	13	14	15	16
Altitude (Boom) ft.	2160	2220	2190	2190	2170	2170	2120	2130
Skid Height ft.								
Gross Weight lb.	6376	6356	6340	6324		6280	6266	6248
Thrust lb.								
IAS (Boom) kt.	67.5	64.5	51.5	51.5	51.0	51.0	40.0	40.0
Time min:sec.	0:28.1	0:26.8	0:37.6	0:34.3	0:21.7	0:23.1	0:27.4	0:29.1
Fuel Used gal.	51.1	54.1	56.7	59.4		66.3	68.5	71.4
N_1 percent								
N_R Rotor rpm								
High Torque Press. in. Hg								
Low Torque Press. in. Hg								
OAT °C	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75
$T_{t_{av}}$ °C								
T_{t_1} °C								
P_{t_1} in. H_2O								
P_{s_1} in. H_2O								
P_{s_4} in. Hg								
P_{t_5} in. Hg								
T_{t_5} °C								
Altitude (Ref) ft.								
COURSE LENGTH - FT.	3580	3580	3580	3580	2095	2095	2095	2095

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 5[illegible]-2076

Pilot CAPT BALFE

Test AIRSPEED CALIBRATION   Flight No. 4   Date 5 Oct 60

ESGW 6700 lb.   FSW 6.34 lb/gal.

Point No.	17	18	19	20	21	22	23	24
Altitude (Boom) ft.	2120	2160	2160	2130	2150	2150	2150	2150
Skid Height ft.								
Gross Weight lb.	6233	6215	6185	6170	6154	6143		
Thrust lb.								
IAS (Boom) kt.	31.0	31.0	25.0	25.0	17	17	121	121
Time min:sec.	0:34.6	0:38.0	0:40.7	0:45.4	0:55.3	0:57.6	0:15.9	0:16.7
Fuel Used gal.	73.8	76.6	81.2	83.6	86.1	88.0		
N_1 percent								
N_R Rotor rpm								
High Torque Press. in. Hg								
Low Torque Press. in. Hg								
OAT °C	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75
$T_{t_{a4}}$ °C								
T_{t_4} °C								
P_{t_4} in. H_2O								
P_{s_4} in. H_2O								
P_{s_4} in. Hg								
P_{t_5} in. Hg								
T_{t_5} °C								
Altitude (Ref) ft.								
COURSE LENGTH - FT	2095	2095	2095	2095	2095	2095	3580	3580

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 57-2076

Pilot CAPT BALFE

Test AIRSPEED CALIBRATION Flight No. 4 Date 5 Oct 60

ESGW 6700 lb. FSW 6.34 lb/gal.

Point No.	25	26	27						
Altitude (Boom) ft.	2140	2170	2180						
Skid Height ft.									
Gross Weight lb.									
Thrust lb.									
IAS (Boom) kt.	79.0	79.0	79.0						
Time min:sec.									
Fuel Used gal.									
N_1 percent									
N_R Rotor rpm									
High Torque Press. in. Hg									
Low Torque Press. in. Hg									
OAT °C	17.75	17.75	17.75						
$T_{t_{as}}$ °C									
T_{t_1} °C									
P_{t_1} in. H_2O									
P_{s_1} in. H_2O									
P_{s_4} in Hg									
P_{t_3} in. Hg									
T_{t_5} °C									
Altitude (Ref) ft.									

Remarks

7'

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test SPEED POWER Flight No. 6 Date 6 Oct 60

ESGW 7625 lb. FSW 6.23 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	6930	7120	7315	7370	7420	7470	7470	7610
Skid Height ft.								
Gross Weight lb.	7525	7497	7477	7465	7447	7427	7401	7379
Thrust lb.								
IAS (Boom) kt.	96.0	85.0	75.0	70.0	55.0	46.0	38.0	25.0
Time min:sec.								
Fuel Used gal.	16.0	20.5	23.7	26.6	29.5	31.8	35.9	39.4
N_1 percent	96.7	94.3	90.7	91.5	87.9	88.7	89.6	92.9
N_R Rotor rpm	322	322	322.5	322.5	323	322.5	323	322.5
High Torque Press. in. Hg	106.8	98.0	85.5	86.7	77.3	78.4	82.5	91.1
Low Torque Press. in. Hg	48.4	45.8	43.9	43.5	41.8	42.0	42.9	44.7
OAT °C	15	15	15	14	14	13	13	13
$T_{t_{as}}$ °C								
T_{t_1} °C	18	16	16	15	15	17	17	17
P_{t_1} in. H_2O	1.6	1.0	-0.7	-0.5	-0.7	-0.9	-1.1	-1.5
P_{s_1} in. H_2O	-27.7	-26.4	-24.8	-24.3	-22.4	-22.9	-25.8	-27.5
P_{s_4} in. Hg	140.25	131.9	120.6	120.7	112.8	112.9	117.1	125.25
P_{t_5} in. Hg	138.7	140.4	119.3	119.4	111.4	111.6	115.9	123.9
T_{t_5} °C	258	246	231	231	219	220	226	240
Altitude (Ref) ft.	7240	7360	7460	7490	7565	7525	7560	7750

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2076

Pilot [illegible]

Test SPEED POWER Flight No. 6 Date 6 Oct 60

ESGW 7625 lb. FSW 6.23 lb/gal.

Point No.	9	10	11	12	13	14	15	
Altitude (Boom) ft.	7820	7420	8070	8060	8200	8370	8370	
Skid Height ft.								
Gross Weight lb.	7350	7329	7245	7230	7214	7199	7178	
Thrust lb.								
IAS (Boom) kt.	12.	65	76.5	57.5	54.0	41.0	24.0	
Time min:sec.								
Fuel Used gal.	44.1	47.5	61.0	63.4	66.0	68.3	71.7	
N_1 percent								
N_R Rotor rpm	322	322.5	290.5	290.5	290.5	290	289	
High Torque Press. in. Hg	101.0	77.1	117.7	84.9	88.0	75.9	94.7	
Low Torque Press. in. Hg	46.0	42.2	47.6	41.8	42.0	41.8	43.2	
OAT °C	13	13	12.5	12.5	12.5	11.6	11.6	
$T_{t_{as}}$ °C								
T_{t_1} °C	17	14	14	15	15	15	16	
P_{t_1} in. H_2O	-1.7	-0.6	-0.7	-0.9	-1.1		-1.5	
P_{s_1} in. H_2O	-29.6	-23.3	-24.7	-23.2	-24.1	-24.0	-26.9	
P_{s_4} in. Hg	130.4	112.4	120.5	113.7	116.1	114.1	121.7	
P_{t_5} in. Hg	129.65	111.2	114.3	112.7	115.2	113.1	120.6	
T_{t_5} °C	249	242	234	224	228	225	238	
Altitude (Ref) ft.	8940	9035	8310	8200	8370	8580	8560	

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 5[illegible]-20[illegible]

Pilot CAPT BALEE

Test SPEED POWER Flight No. 8 Date 10 Oct 60

ESGW 7674 lb. FSW 6.54 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	8505	8470	9075	9250	9285	9455	9650	9620
Skid Height ft.								
Gross Weight lb.	7448	7367	7348	7315	7374	7254	7235	7191
Thrust lb.								
IAS (Boom) kt.	0	48.0	92.5	82.0	73.5	63.0	49.0	36.5
Time min:sec.								
Fuel Used gal.	35.6	48.5	51.5	56.6	59.0	66.3	69.3	76.1
N_1 percent	100	100	97.2	92.6	90.3	88.6	87.9	88.8
N_R Rotor rpm	313.5	317.5	313.5	313.5	314	314	314	314.5
High Torque Press. in. Hg	118.6	118.5	107.5	93.7	86.1	81.0	79.2	81.0
Low Torque Press. in. Hg	48.1	47.3	44.8	42.0	41.1	40.4	39.8	40.2
OAT °C	4.5	2.0	0	0	0	-1.5	-1.5	-2.0
$T_{t_{as}}$ °C								
T_{t_1} °C	1.0	1.0	1.0	0	0	1.0	2.0	4.0
P_{t_1} in. H_2O	-4.0	-0.5	-0.5	-0.5	-0.55	-0.7	-0.9	-1.1
P_{s_2} in. H_2O	-35.2	-32.3	-29.9	-26.2	-24.1	-23.1	-22.7	-23.9
P_{s_4} in. Hg	146.5	147.8	137.7	124.7	118.1	113.1	110.3	112.5
P_{t_5} in. Hg	144.6	145.9	135.7	122.7	116.1	111.3	108.5	110.7
T_{t_5} °C	258	256	246	227	217	209	206	209
Altitude (Ref) ft.	8375	8710	9190	9325	9340	9460	9640	9585

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test SPEED POWER   Flight No. 8   Date 10 Oct 60

ESGW 7674 lb.   FSW 6.34 lb/gal.

Point No.	9	10						
Altitude (Boom) ft.	9650	9770						
Skid Height ft.								
Gross Weight lb.	7169	7132						
Thrust lb.								
IAS (Boom) kt.	23	18						
Time min:sec.								
Fuel Used gal.	79.7	85.6						
N_1 percent	91.8	93.4						
N_R Rotor rpm	314.5	314.5						
High Torque Press. in.Hg	89.8	45.1						
Low Torque Press. in. Hg	42.1	42.9						
OAT °C	-2.5	-1.5						
$T_{t_{ea}}$ °C								
T_{t_1} °C	4.5	3.0						
P_{t_1} in. H_2O	-1.5	-1.4						
P_{s_1} in. H_2O	-26.5	-27.6						
P_{s_4} in. Hg	120.0	123.8						
P_{t_5} in. Hg	116.2	121.9						
T_{t_5} °C	224	227						
Altitude (Ref) ft.	9690	9825						

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 5[illegible]-20[illegible]6

Pilot CALT BALEY

Test SPEED POWER Flight No. 10 Date 13 Oct 60

ESGW 6374 lb. FSW 6.29 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	8535	8720	8655	8855	8870	8995	9045	9050
Skid Height ft.								
Gross Weight lb.	6124	6109	6097	6075	6058	6043	6030	6027
Thrust lb.								
IAS (Boom) kt.	112	102	92	84.5	80.0	65.5	61	60
Time min:sec.								
Fuel Used gal.	38.4	42.2	45.7	47.5	50.2	52.7	54.7	55.2
N_1 percent	99.5	95.1	91.2	89.5	88.0	86.1	86.0	86.0
N_R Rotor rpm	323	324	323.5	323.5	324	323.5	324	324
High Torque Press. in. Hg	110.4	95.0	87.8	79.9	76.0	70.7	72.6	70.1
Low Torque Press. in. Hg	46.9	44.6	42.6	41.3	40.6	39.4	39.3	39.2
OAT °C	8.8	8.8	8.3	7.8	7.8	7.8	6.8	6.8
T_{tes} °C	552	499	467	442	432	417	415	415
T_{t1} °C	8.5	8.5	8	8	7.5	8	8.5	8
P_{t1} in. H_2O	0	0	-0.1	-0.1	0.3	-0.4	-0.5	-0.6
P_{s1} in. H_2O	-37.6	-26.8	-24.0	-22.4	-21.7	-20.2	-20.2	-20.2
P_{s4} in. Hg	140.5	127.3	117.5	112.1	108.4	102.8	102.4	102.1
P_{t3} in. Hg	142.2	129.3	119.3	113.9	110.2	104.45	104.0	103.8
T_{t3} °C	260	242	227	220	214	207	206	206
Altitude (Ref) ft.	8675	8810	8750	8890	8930	8965	9005	9005

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot Capt Bailey

Test Speed Power   Flight No. 10   Date 13 Oct 60

ESGW 6374 lb.   FSW 6.29 lb/gal.

Point No.	9	10	11	12	13	14		
Altitude (Boom) ft.	9120	9225	9140	9535				
Skid Height ft.								
Gross Weight lb.	6021	6006	5986	5962				
Thrust lb.								
IAS (Boom) kt.	49	36	29	17				
Time min:sec.								
Fuel Used gal.	56.2	58.5	61.7	65.5				
N_1 percent	85.6	86.3	87.9	91.1				
N_R Rotor rpm	323	323.5	324	323				
High Torque Press. in. Hg	69.4	70.3	75.8	84.2				
Low Torque Press. in. Hg	39.2	39.1	40.4	41.5				
OAT °C	7.8	7.8	7.8	7.8				
T_{t5} °C	413	418	430	470				
T_{t1} °C	9	10.5	12	12				
P_{t1} in. H_2O	-0.5	-1.0	-1.2	-1.3				
P_{s1} in. H_2O	-20.2	-20.9	-22.7	-25.0				
P_{s4} in. Hg	101.1	101.8	106.9	114.3				
P_{t3} in. Hg	102.8	103.6	108.6	115.8				
T_{t3} °C	200	208	217	227				
Altitude (Ref) ft.	9060	9140	9055	9440				

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot: CAPT BALFE

Test: SPEED POWER   Flight No. 11   Date 14 Oct 60

ESGW 6360 lb.   FSW 6.30 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	7950	8020	8190	8240	8680	8660	8810	9050
Skid Height ft.								
Gross Weight lb.	6257	6241	6207	6197	6170	6149	6133	6121
Thrust lb.								
IAS (Boom) kt.	113	105.5	97.5	85	76	64.5	60.0	54.0
Time min:sec.								
Fuel Used gal.	17.9	20.5	24.3	27.5	30.2	33.6	36.0	38.8
N_1 percent	97.9	95.5	92.5	89.1	[illegible]	85.5	85.3	84.7
N_R Rotor rpm	314	313.5	313.5	313.5	[illegible]	313	313	314
High Torque Press. in. Hg	116.0	106.5	94.4	83.0	78.6	72.1	71.1	69.5
Low Torque Press. in. Hg	50.0	47.3	45.2	42.3	41.6	40.1	39.5	39.0
OAT °C	5.8	5.8	4.8	4.8	3.8	3.3	2.8	1.8
$T_{t_{4.5}}$ °C	564	502	472	437	422	402	400	400
T_{t_1} °C	4.1	4.1	4.1	3.0	3.0	3.0	4.1	4.1
P_{t_1} in. H_2O	-0.4	-0.3	-0.3	-0.2	-0.35	-0.6	-0.7	-0.8
P_{s_1} in. H_2O	-31.9	-28.7	-26.1	-23.4	-22.6	-20.8	-20.8	-20.6
P_{s_4} in. Hg	148.1	136.4	127.3	116.7	111.2	105.8	104.1	102.5
P_{t_3} in. Hg	146.7	135.0	125.7	115.3	110.5	104.5	102.9	101.2
T_{t_3} °C	259	241	227	214	208	200	197	196
Altitude (Ref) ft.	9140	9130	8265	8355	8720	8650	8815	9020

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test SPEED POWER Flight No. 11 Date 14 Oct 60

ESGW 6360 lb. FSW 6.30 lb/gal.

Point No.	9	10	11	12				
Altitude (Boom) ft.	9100	9140	9180	9290				
Skid Height ft.								
Gross Weight lb.	6099	6091	6075	6051				
Thrust lb.								
IAS (Boom) kt.	43.0	36.0	32.0	20.0				
Time min:sec.								
Fuel Used gal.	41.5	42.7	45.2	49.0				
N_1 percent	85.7	86.8	86.9	86.0				
N_R Rotor rpm	314	314	313	314				
High Torque Press. in. Hg	70.9	74.2	73.9	83.2				
Low Torque Press. in. Hg	39.4	40.0	39.6	41.6				
OAT °C	1.8	1.8	1.3	1.8				
$T_{t_{es}}$ °C	402	412	417	452				
T_{t_1} °C	4.1	5.2	5.2	6.2				
P_{t_1} in. H_2O	-0.95	-1.1	-1.15	-1.3				
P_{s_1} in. H_2O	-20.3	-21.2	-22.4	-22.5				
P_{s_4} in. Hg	104.3	107.1	107.0	115.1				
P_{t_5} in. Hg	103.0	105.8	105.7	113.9				
T_{t_5} °C	200	200	200	215				
Altitude (Ref) ft.	9050	9120	9140	9215				

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test SPEED POWER Flight No. 12 Date 14 Oct 60

ESGW 6360 lb. FSW 6.30 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	8360	8250	8350	8470	8415	8505	8750	8920
Skid Height ft.								
Gross Weight lb.	6234	6214	6194	6166	6153	6140	6129	6107
Thrust lb.								
IAS (Boom) kt.	111	98	88.5	77.5	63	53	44.5	32.5
Time min:sec.								
Fuel Used gal.	19.9	23.2	26.4	27.6	[illegible]	34.9	36.7	40.2
N_1 percent	99.6	92.6	89.8	87.0	84.7	84.6	84.4	86.7
N_R Rotor rpm	314.5	314	313.5	313.5	313.5	314	312.5	314
High Torque Press. in. Hg	116.7	94.6	86.2	77.2	71.3	70.9	69.9	76.1
Low Torque Press. in. Hg	49.2	45.4	43.5	41.8	40.5	40.3	39.9	41.0
OAT °C	4.8	3.8	4.3	4.3	4.3	3.8	3.8	2.9
T_{t_5} °C	577	482	462	427	407	407	407	422
T_{t_1} °C	5	5	4	4	5	6.5	6.5	6.5
P_{s_1} in. H_2O	-31.3	-26.9	-24.2	-22.3	-20.7	-20.7	-20.6	-23.0
P_{t_1} in. H_2O	-0.3	-0.45	-0.25	-0.45	-0.55	-0.70	-0.75	-1.10
P_{s_4} in. Hg	146.4	128.1	120.2	111.8	105.7	104.9	102.8	109.1
P_{t_3} in. Hg	144.9	126.4	118.7	110.2	104.2	103.4	101.5	107.6
T_{t_3} °C	256	230	220	208	195	198	196	230
Altitude (Ref) ft.	8310	8220	8280	8420	8400	8465	8900	8890

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2076

Pilot CAPT BALEE

Test SPEED POWER Flight No. 12 Date 14 Oct 60

ESGW 6360 lb. FSW 6.30 lb/gal.

Point No.	9							
Altitude (Boom) ft.	8895							
Skid Height ft.								
Gross Weight lb.	6092							
Thrust lb.								
IAS (Boom) kt.	20							
Time min:sec.								
Fuel Used gal.	42.5							
N_1 percent	88.4							
N_R Rotor rpm	314							
High Torque Press. in. Hg	83.8							
Low Torque Press. in. Hg	42.2							
OAT °C	2.9							
$T_{t_{4.5}}$ °C	457							
T_{t_1} °C	6.5							
P_{s_1} in. H_2O	-25.1							
P_{t_1} in. H_2O	-1.20							
P_{s_4} in. Hg	116.1							
P_{t_5} in. Hg	114.7							
T_{t_5} °C	215							
Altitude (Ref) ft.	8865							

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 5[illegible]-207[illegible]

Pilot CAPT BALFE

Test SPEED POWER Flight No. 13 Date 15 Oct 60

ESGW 6740 lb. FSW 6.28 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	13980	13890	13955	13920	13950	14010	14040	13975
Skid Height ft.								
Gross Weight lb.	6524	6486	6483	6468	6461	6448	6438	6426
Thrust lb.								
IAS (Boom) kt.	61.5	57	53	49	44	39	34	27
Time min:sec.								
Fuel Used gal.	37.5	40.4	41.0	43.3	44.5	46.4	48.1	50.0
N_1 percent	96.4	97.2	93.9	93.1	92.6	92.6	92.8	95.1
N_R Rotor rpm	294.5	296	296	295	295	295	296	296
High Torque Press. in. Hg	94.4	96.5	87.6	86.2	85.3	85.1	85.1	90.2
Low Torque Press. in. Hg	38.5	38.8	37.2	36.6	36.6	36.3	36.1	37.0
OAT °C	-7	-8	-8	-8.5	-8	-8	-9	-8
$T_{t_{4a}}$ °C	515	522	477	472	467	467	470	500
T_{t_1} °C	-6	-6	-6	-6	-5	-4	-4	-4
P_{t_1} in. H_2O	-0.75	-0.95	-0.95	-1.0	-1.1	-1.1	-1.2	-1.2
P_{s_1} in. H_2O	-26.6	-26.1	-24.2	-23.8	-23.7	-23.7	-23.9	-26.4
P_{s_4} in. Hg	115.5	116.6	109.1	107.5	106.7	106.2	106.4	111.4
P_{t_3} in. Hg	114.2	115.3	107.7	106.1	105.4	105.0	105.2	110.0
T_{t_3} °C	257	259	222	223	217	217	218	226
Altitude (Ref) ft.	14020	13910	13960	13920	13950	14015	14040	13960

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test SPEED POWER Flight No. 13 Date 15 Oct 60

ESGW 6740 lb. FSW 6.28 lb/gal.

Point No.	9	10	11					
Altitude (Boom) ft.	14100	14300	14050					
Skid Height ft.								
Gross Weight lb.	6394	6392	6368					
Thrust lb.								
IAS (Boom) kt.	21	19	41					
Time min:sec.								
Fuel Used gal.	54.8	55.4	69.2					
N_1 percent		99.7	91.1					
N_R Rotor rpm		296	295					
High Torque Press. in. Hg		101.0	99.7					
Low Torque Press. in. Hg		38.9	34.4					
OAT °C	-8	-7	-8					
T_{t_5} °C		550	460					
T_{t_1} °C		-5	-3					
P_{t_1} in. H_2O		-1.3	-1.1					
P_{s_1} in. H_2O		-27.6	-22.4					
P_{s_4} in. Hg		119.7	101.9					
P_{t_3} in. Hg		118.5	100.7					
T_{t_3} °C		244	212					
Altitude (Ref) ft.		14300	14020					

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test SPEED POWER Flight No. 18 Date 25 Oct 60

ESGW 5800 lb. FSW 6.28 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	2750	2530	2860	2850	2850	2885	2945	3240
Skid Height ft.								
Gross Weight lb.	5744	5707	5675	5659	5642	5622	5604	5672
Thrust lb.								
IAS (Boom) kt.	125	109	97.5	85	74	62	53	36
Time min:sec.								
Fuel Used gal.	9.8	15.8	20.9	23.4	26.1	29.2	32.1	37.3
N_1 percent	99.6	95.4	92.9	90.5	84.8	83.6	83.6	84.3
N_R Rotor rpm	322.5	323.5	322.5	322.0	322	322.5	322.6	322.6
High Torque Press. in. Hg	125.6	102.4	92.2	81.7	76.9	73.0	71.6	73.2
Low Torque Press. in. Hg	56.3	51.8	49.4	46.8	46.2	46.3	45.0	45.1
OAT °C	19.5	15.5	18.5	18.0	18.5	18.5	18.5	17.5
$T_{t_{5}}$ °C	532	465	441	429	437	439	437	442
T_{t_1} °C	18.7	15.5	17.7	19.3	18.7	19.8	20.3	21.3
P_{t_1} in. H_2O	-0.27	0.22	-0.17	-0.22	-0.42	-0.67	-0.77	-1.16
P_{s_1} in. H_2O	-35.1	-29.92	-26.2	-23.8	-22.4	-21.4	-21.5	-22.7
P_{s_4} in. Hg	165.9	147.5	136.1	137.2	121.4	117.1	117.0	117.6
P_{t_3} in. Hg	164.0	145.4	134.0	125.1	119.4	116.1	114.9	115.7
T_{t_3} °C	264	236	228	220	214	208	207	210
Altitude (Ref) ft.	2910	2640	2930	2880	2860	2880	2930	3225

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test SPEED POWER Flight No. 18 Date 25 Oct 60

ESGW 5805 lb. FSW 6.28 lb/gal.

Point No.	9	10	11	12				
Altitude (Boom) ft.	3380	3600	3660	3640				
Skid Height ft.								
Gross Weight lb.	5540	5520	5490	5471				
Thrust lb.								
IAS (Boom) kt.	27.5	16	44	83.5				
Time min:sec.								
Fuel Used gal.	42.6	45.7	50.3	53.2				
N_1 percent	86.0	88.0	83.7	86.7				
N_R Rotor rpm	322.5	322.5	322.5	323				
High Torque Press. in. Hg	76.9	82.1	79.3	79.3				
Low Torque Press. in. Hg	46.0	56.7	53.9	46.4				
OAT °C	18.5	19.5	19.5	19.5				
$T_{t[illegible]}$ °C	441	442	434					
T_{t1} °C	22.8	23.8	21.8	20.8				
P_{t1} in. H_2O	-1.51	-1.51	-1.02	-0.32				
$P_{s[illegible]}$ in. H_2O	-24.4	-26.2	-21.5	-23.2				
P_{34} in. Hg	121.5	127.3	113.7	123.4				
P_{t5} in. Hg	119.7	125.3	111.9	121.5				
T_{t5} °C	218	228	210	221				
Altitude (Ref) ft.	3370	3525	3620	3680				

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test ENGINE CALIBRATION Flight No. 21 Date 1 Nov 60

ESGW ______ lb. FSW ______ lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	3820	3780	3830	3760	3700	3700	3700	3820
Skid Height ft.								
Gross Weight lb.								
Thrust lb.								
IAS (Boom) kt.								
Time min:sec.	1:14.55	1:18.9	1:13.5	1:16.1	1:19.8	1:20.8	1:25.55	1:27.7
Fuel Used gal.	2.0	2.0	1.5	1.5	1.5	1.5	1.5	1.5
N_1 percent	98.4	97.1	91.9	90.8	89.5	88.5	88.0	87.4
N_R Rotor rpm	323	323	323.5	323.5	324.5	324	323.5	323.5
High Torque Press. in. Hg	125.5	119.1	97.5	94.4	90.6	87.1	84.4	83.7
Low Torque Press. in. Hg	55.6	54.9	50.5	50.3	49.8	48.8	48.0	47.6
OAT °C	22	22	22	22	22	21.5	21	21
$T_{t4.5}$ °C	572	542	487	472	462	452	442	441
T_{t1} °C	23	22	21	21	21	21	21	21
P_{t1} in. H_2O	-0.2	-0.1	-0.1	0	-0.1	-0.2	-0.3	-0.45
P_{s1} in. H_2O								
P_{s4} in. Hg								
P_{t5} in. Hg								
T_{t5} °C								
Altitude (Ref) ft.	4070	3920	3920	3830	3730	3750	3740	3640

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test ENGINE CALIBRATION Flight No. 21 Date 1 Nov 60

ESGW ______ lb. FSW ______ lb/gal.

Point No.	9	10	11	12	13	14	15	16
Altitude (Boom) ft.	3840	3860	3800	3570	3560	8100	8280	7990
Skid Height ft.								
Gross Weight lb.								
Thrust lb.								
IAS (Boom) kt.								
Time min:sec.	1:31.2	1:02.9	1:05.5	1:07.1	1:08.9	1:04.4	1:08.5	1:11.6
Fuel Used gal.	1.5	1.0	1.0	1.0	1.0	1.5	1.5	1.5
N_1 percent	86.4	85.7	84.5	83.8	83.0	99.4	98.1	96.5
N_R Rotor rpm	322.5	323	[illegible]3.5	323	323.5	322.5	323.5	324
High Torque Press. in. Hg	79.9	77.2	73.8	72.9	70.7	107.3	102.4	98.8
Low Torque Press. in. Hg	47.0	46.4	45.6	45.3	45.0	48.9	47.6	47.0
OAT °C	21	21.5	21	21	21	17.	17	17.5
T_{t_5} °C	437	442	445	450	447	564	537	525
T_{t_1} °C	21	21	21	21.5	21.5	17.1	16.6	16.6
P_{t_1} in. H_2O	-0.25	-0.4	-0.45	-0.4	-0.6	-0.2	0	+0.005
P_{s_1} in. H_2O								
P_{s_4} in. Hg								
P_{t_5} in. Hg								
T_{t_5} °C								
Altitude (Ref) ft.	3855	3840	3795	3590	3625	8330	8470	8200

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1D USA S/N 5?-2078

Pilot CAPT. BALFE.

Test ENGINE CALIBRATION Flight No. 21 Date 1 NOV 60

ESGW ______ lb. FSW ______ lb/gal.

Point No.	17	18	19	20	21	22	23	24
Altitude (Boom) ft.	8240	8200	8410	8370	8[illegible]40	8360	8340	8260
Skid Height ft.								
Gross Weight lb.								
Thrust lb.								
IAS (Boom) kt.								
Time min:sec.	1:15.1	1:16.4	1:20.7	1:25.1	1:28.5	1:31.8	1:05.9	1:08.9
Fuel Used gal.	1.5	1.5	1.5	1.5	1.5	1.5	1.0	1.0
N_1 percent	95.9	95.1	93.6	92.4	91.4	90.6	88.9	87.3
N_R Rotor rpm	323	323.5	324	324	323.5	324	[illegible]	323.5
High Torque Press. in. Hg	95.1	93.2	88.9	84.5	83.0	79.9	75.1	71.8
Low Torque Press. in. Hg	45.5	45.8	44.3	43.6	43.5	42.7	41.9	40.9
OAT °C	16	16	15	15.5	15.5	15	15.5	16.0
$T_{t_{5c}}$ °C	520	511	497	487	470	454	442	432
T_{t_1} °C	16	15.5	15	15	15	14.5	15	15.5
P_{t_1} in. H_2O	-0.5	0	-0.15	-0.01	-0.02	0	-0.3	-0.2
P_{s_1} in. H_2O								
P_{s_4} in. Hg								
P_{t_5} in. Hg								
T_{t_5} °C								
Altitude (Ref) ft.	8390	8395	8570	8520	8470	8485	8450	8360

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test ENGINE CALIBRATION Flight No. 21 Date 1 Nov 60

ESGW ______ lb. FSW ______ lb/gal.

Point No.	25	26	27	28	29	30	31	32
Altitude (Boom) ft.	8260	8280	8180	13170	13140	13320	13300	13430
Skid Height ft.								
Gross Weight lb.								
Thrust lb.								
IAS (Boom) kt.								
Time min:sec.	1:12.3	1:17.3	1:18.0	1:13.6	1:25.5	1:41.8	1:47.6	1:15.4
Fuel Used gal.	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.0
N_1 percent	86.5	84.9	84.6	99.9	93.3	91.9	90.2	88.5
N_R Rotor rpm	323	323	323	320.5	323.5	324	324	323
High Torque Press. in. Hg	69.1	65.4	64.5	96.6	78.5	74.3	70.9	68.0
Low Torque Press. in. Hg	40.2	39.4	38.9	41.5	37.5	36.9	36.0	35.5
OAT °C	15.5	15	15.5	5	5.5	6.6	6.6	5
$T_{t_{ex}}$ °C	430	437	440	564	482	474	454	441
T_{t_1} °C	15	15	15	4	5	5	5	4.5
P_{t_1} in. H_2O	-0.35	-0.4	-0.5	-0.2	0	-0.25	-0.2	-0.3
P_{s_1} in. H_2O								
P_{s_4} in. Hg								
P_{t_5} in. Hg								
T_{t_5} °C								
Altitude (Ref) ft.	8280	8290	8180	13400	13330	13475	13450	13560

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1D USA S/N 58-2078

Pilot CAPT BAKER

Test ENGINE CALIBRATION Flight No. 21 Date 1 Nov 60

ESGW ______ lb. FSW ______ lb/gal.

Point No.	33	34	35	36				
Altitude (Boom) ft.	13300	13190	13320	13370				
Skid Height ft.								
Gross Weight lb.								
Thrust lb.								
IAS (Boom) kt.								
Time min:sec.	1:19.2	1:23.2	1:25.5	1:27.6				
Fuel Used gal.	1.0	1.0	1.0	1.0				
N_1 percent	87.9	86.8	86.1	85.4				
N_R Rotor rpm	324	324	323.5	323.5				
High Torque Press. in. Hg	65.4	62.9	61.2	59.5				
Low Torque Press. in. Hg	35.2	34.6	34.3	34.0				
OAT °C	5	4.5	4.5	4				
T_{tex} °C	429	420	417	414				
T_{t1} °C	5	5	5	5				
P_{t1} in. H_2O	-0.2	-0.4	-0.5	-0.5				
P_{s1} in. H_2O								
P_{s4} in. Hg								
P_{t3} in. Hg								
T_{t3} °C								
Altitude (Ref) ft.	13430	13380	13410	13435				

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot LT. COLVIN

Test TETHERED HOVERING Flight No. 29 Date 19 APR 61

ESGW 6620 lb. FSW 6.31 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	2215	2205	2195	2195	2185	2215	2205	2195
Skid Height ft.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Gross Weight lb.								
Thrust lb.	7655	8696	9325	9642	9971	6889	7519	8017
IAS (Boom) kt.								
Time min:sec.								
Fuel Used gal.	16.9	19.5	21.7	23.7	27.1	33.8	35.3	37.2
N_1 percent	90	93	94.9	96.5	97.3	88.3	90.0	91.5
N_R Rotor rpm	321.5	320	322	322	319	314	313	312.5
High Torque Press. in. Hg								
Low Torque Press. in. Hg								
OAT °C	9	8.5	8.5	8.5	8.5	8.5	8.5	8.5
$T_{t_{5}}$ °C								
T_{t_1} °C								
P_{t_1} in. H_2O								
P_{s_1} in. H_2O								
P_{s_4} in. Hg								
P_{t_5} in. Hg								
T_{t_5} °C								
Altitude (Ref) ft.								
Δ TORQUE - PSI	28.6	31.5	33.8	35.9	37.5	25.3	27.7	29.4

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2076

Pilot LT COLVIN

Test TETHERED HOVERING Flight No. 29 Date 14 APR 61

ESGW 6620 lb. FSW 6.31 lb/gal.

Point No.	9	10	11	12	13	14	15	16
Altitude (Boom) ft.	2195	2195	2195	2335	2375	2375	2335	2325
Skid Height ft.	1.0	1.0	1.0	59.0	59.0	59.0	59.0	59.0
Gross Weight lb.								
Thrust lb.	8655	9160	9860	7772	8264	8334	8369	6390
IAS (Boom) kt.								
Time min:sec.								
Fuel Used gal.	39.2	41.6	44.6	53.9	56.8	61.5	63.9	70.1
N_1 percent	93.5	94.9	97.0	94.1	95.4	97.0	97.4	89.6
N_R Rotor rpm	312.5	313	313	322	322	323	320	289
High Torque Press. in. Hg								
Low Torque Press. in. Hg								
OAT °C	8.5	8.5	8.5	10	10	10	10	10
$T_{t_{2a}}$ °C								
T_{t_1} °C								
P_{t_1} in. H_2O								
P_{s_1} in. H_2O								
P_{s_4} in. Hg								
P_{t_5} in. Hg								
T_{t_5} C								
Altitude (Ref) ft.								
Δ TORQUE – PSI	32.6	34.5	37.8	35.1	36.9	38.2	39.2	29.9

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot Lt. Colvin

Test TETHERED HOVERING Flight No. 29 Date 14 APR 61

ESGW 6620 lb. FSW 6.31 lb/gal.

Point No.	17	18	19	20	21	22	23	24
Altitude (Boom) ft.	2325	2315	2315	2315	2295	2295	2300	2315
Skid Height ft.	59.0	59.0	59.0	59.0	69.0	59.0	69.0	59.0
Gross Weight lb.								
Thrust lb.	6949	7343	7569	7998	6431	6836	7462	7969
IAS (Boom) kt.								
Time min:sec.								
Fuel Used gal.	71.8	73.3	76.5	79.7	82.6	84.9	87.2	90.9
N_1 percent	91.5	93.0	94.3	95.8	90.6	91.9	93.4	96.0
N_R Rotor rpm	289.5	289	289	290.5	313	314	313	314
High Torque Press. in. Hg								
Low Torque Press. in. Hg								
OAT °C	10	10	10	10	10	10	10	10
$T_{t_{?}}$ °C								
T_{t_1} °C								
P_{t_1} in. H_2O								
P_{s_1} in. H_2O								
P_{s_2} in. Hg								
P_{t_2} in. Hg								
T_{t_2} °C								
Altitude (Ref) ft.								
Δ TORQUE - PSI	33.1	35.5	38.3	40.2	29.1	31.3	33.3	37.8

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
HU-1B USA S/N 58-2078

Pilot LT COLVIN

Test TETHERED HOVERING Flight No. 29 Date 19 APR 61

ESGW 6620 lb. FSW 6.31 lb/gal.

Point No.	25	26							
Altitude (Boom) ft.	2295	2295							
Skid Height ft.	590	06E							
Gross Weight lb.									
Thrust lb.	8377	5978							
IAS (Boom) kt.									
Time min:sec.									
Fuel Used gal.	94.4	102.0							
N_1 percent	97.4	89.0							
N_R Rotor rpm	311	322							
High Torque Press. in. Hg									
Low Torque Press. in. Hg									
OAT °C	10	10							
$T_{t_{av}}$ °C									
T_{t_2} °C									
P_{t_2} in. H_2O									
P_{s_2} in. H_2O									
P_{s_4} in. Hg									
P_{t_5} in. Hg									
T_{t_5} °C									
Altitude (Ref) ft.									
Δ TORQUE - PSI	40.0	25.0							

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALEE

Test TETHERED HOVERING Flight No. 34 Date 25 April/61

ESGW 6460 lb. FSW 6.34 lb/gal.

Point No.	1	2	3	4	5	6	7	8
Altitude (Boom) ft.	2150	2140	2140	2150	2150	2150	2150	2140
Skid Height ft.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Gross Weight lb.								
Thrust lb.	8962	9675	10027	6467	7026	7351	7668	8[illegible]4
IAS (Boom) kt.								
Time min:sec.								
Fuel Used gal.	19.5	25.3	29.0	39.1	40.8	42.5	44.5	46.7
N_1 percent	93.3	96.6	97.5	86.4	87.8	88.9	90.2	92.2
N_R Rotor rpm	321.5	322	322	290.5	290	290.5	290	290
High Torque Press. in. Hg								
Low Torque Press. in. Hg								
OAT °C	5	5	5	5	5	5	5	5
$T_{t_{av}}$ °C								
T_{t_1} °C								
P_{t_1} in. H_2O								
P_{s_1} in. H_2O								
P_{s_2} in. Hg								
P_{t_2} in. Hg								
T_{t_2} °C								
Altitude (Ref) ft.								
Δ TORQUE - PSI	31.2	35.4	36.6	23.0	25.0	27.2	29.0	33.0

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot CAPT BALFE

Test TETHERED HOVERING Flight No. 34 Date 25 APR 61

ESGW 6460 lb. FSW 6.34 lb/gal.

Point No.	9	10	11	12	13	14	15	16
Altitude (Boom) ft.	2140	2140	2140	2140	2140	2130	2120	2120
Skid Height ft.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Gross Weight lb.								
Thrust lb.	9026	9267	9546	7061	7865	8239	8501	8958
IAS (Boom) kt.								
Time min:sec.								
Fuel Used gal.	48.7	50.9	52.7	3.5	5.2	7.6	28.8	31.5
N_1 percent	94.[illegible]	96.5	96.9	88.1	91.1	92.3	93.5	93.5
N_R Rotor rpm	290.5	290.5	290	322	322	322	290	290.5
High Torque Press. in. Hg								
Low Torque Press. in. Hg								
OAT °C	5	5	5	13	13	13	13	13
$T_{t_{ex}}$ °C								
T_{t_1} °C								
P_{t_1} in. H_2O								
P_{s_1} in. H_2O								
P_{s_4} in. Hg								
P_{t_4} in. Hg								
T_{t_4} °C								
Altitude (Ref) ft.								
Δ TORQUE – PSI	35.2	36.6	39.1	26.9	28.0	28.5	33.4	35.5

Remarks

TEST DATA CORRECTED FOR INSTRUMENT ERROR
YHU-1B USA S/N 58-2078

Pilot LT Colvin

Test FREE FLIGHT HOVERING Flight No. 40 Date 17 May 1961

ESGW 6546 lb. FSW 6.34 lb/gal.

Point No.	1	2	3	4	5	6		
Altitude (Boom) ft.	5730	6130	7900	9100	11460			
Skid Height ft.								
Gross Weight lb.	6435	6412	6354	6320	6289			
Thrust lb.								
IAS (Boom) kt.								
Time min:sec.								
Fuel Used gal.	17.5	21.2	30.3	35.6	40.8			
N_1 percent	92.7	93.8	95.4	95.4	97.4			
N_R Rotor rpm	320	321	320	322	314			
High Torque Press. in.Hg								
Low Torque Press. in. Hg								
OAT °C	16.5	16.5	12	11	7			
$T_{t_{ex}}$ °C								
T_{t_1} °C								
P_{t_1} in. H_2O								
P_{s_1} in. H_2O								
P_{s_4} in. Hg								
P_{t_3} in. Hg								
T_{t_3} °C								
Altitude (Ref) ft.								
Δ TORQUE - PSI	29.4	29.3	30.6	29.5	30.6			

Remarks

ASTIA DOCUMENT NO. AD-

Air Force Flight Test Center
Flight Test Engineering Division
Edwards AFB, California

YHU-1B Category I Performance, Stability and Control Tests. By J. F. Westphal, Captain, USAF and P. J. Belfe, Captain, USAF. July 1961. Pages. (AFFTC-TR-61-39).

The YHU-1B was tested by the AFFTC to gather limited performance and stability and control data to determine whether the helicopter will meet performance guarantees and to insure that no serious stability and control problems exist.

The test aircraft was a modified HU-1 with HU-1B dynamic components such as the rotor system, tail rotor, transmission, etc. No changes are programmed for the production HU-1B aircraft that will affect performance and stability.

The flying qualities of the YHU-1B are very good. In general, the flying qualities are improved over the earlier HU-1 series. This improvement stems primarily from the absence of the objectionable pitch and roll

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The helicopter meets all contractor guarantees for range, hovering, cruise speed, and service ceiling. However, it is felt that fuel capacity should be increased over the proposed 165 gallons to allow more adequate reserve for flight under instrument conditions. When compared to the HU-1A the YHU-1B has improved altitude performance, cruise speed, range and load carrying capabilities.

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